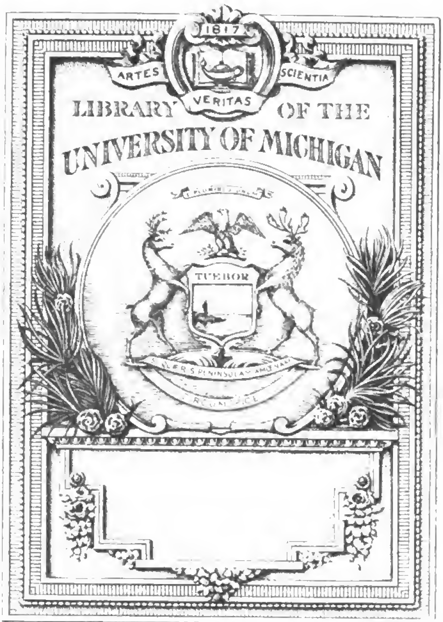

1817
ARTES
SCIENTIA
VERITAS
LIBRARY OF THE
UNIVERSITY OF MICHIGAN
TUEBOR

TM 1-235

U. S. WAR DEPARTMENT

TECHNICAL MANUAL

THE WEATHER OBSERVER

June 29, 1942

Sci-Lib
Gen'l.
Sugh Winns
11-20-42

TECHNICAL MANUAL No. 1-235

WAR DEPARTMENT, WASHINGTON, June 29, 1942.

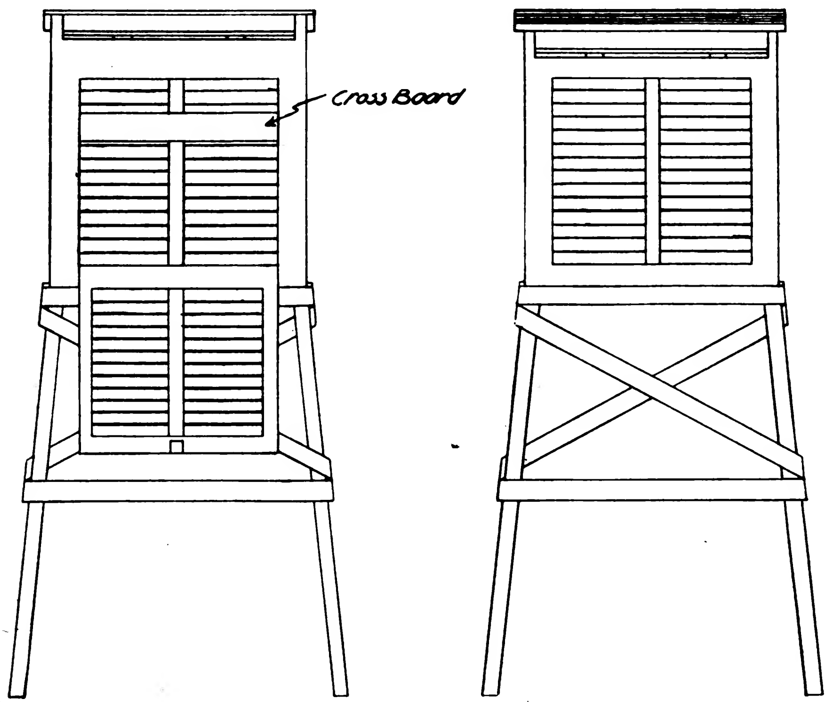
THE WEATHER OBSERVER

Section I

WEATHER INSTRUMENTS

1. **Instrument shelter.**—*a. Purpose.*—The instrument shelter is used as a means of properly exposing the dry- and wet-bulb thermometers, the maximum thermometer, the minimum thermometer, the thermograph and the hygrograph. In the collection of data for scientific study, care must constantly be exercised to insure that only truly representative values are observed and recorded. In observing the temperature and humidity of the air during the conduct of a meteorological observation, we are not interested in measuring the temperature or the humidity of a mass of air that is confined in a hot room, or in a cold room, or of air that lies close to a surface of asphalt pavement on a hot summer day, or close to a snow covered surface. Such measurements would largely reflect the temperature and humidity values of the particular environment or the adjacent

surface covering, and would not be representative of an unconfined stratum of air that was free to be mixed thoroughly by its normal and usual motion. We are interested in measuring the temperature and humidity of such free air, i. e., air that is free to be mixed thoroughly and in a natural environment. At the same time, we wish to have the stratum of air in which we are to take the observations unaffected by conduct of heat to or from any body. It should be shielded from direct radiation from the sun, from radiation from ground surfaces



① Front view. ② Rear view.

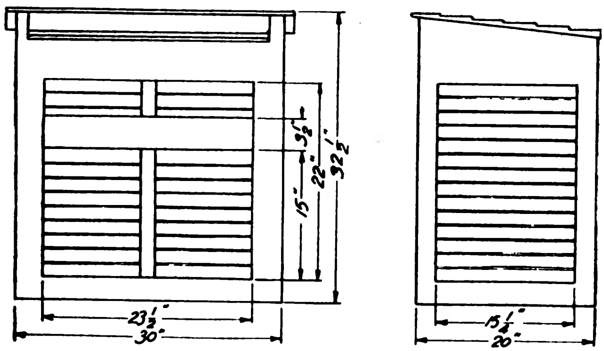
FIGURE 1.—Instrument shelter.

and walls of buildings, and from sky radiation. The instrument shelter also serves a final purpose—to keep the instruments dry.

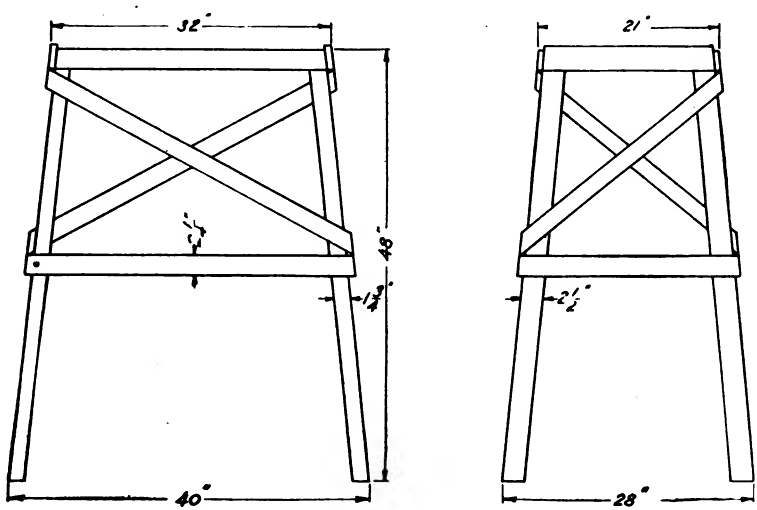
b. Description and specifications.—Sketches of an instrument shelter, front and rear, are shown in figure 1. The shelter consists of a wooden box, with double roof, louvered sides, and a slotted floor. Such construction permits the air to move through it with the greatest possible freedom while, at the same time, the instruments are protected from snow and rain. To minimize the effects of radiation and conduc-

tion of heat, shelters are always made of wood and are painted white. Dimensional specifications of the instrument shelter are shown in figure 2.

c. *Installation.*—(1) The shelter should be installed, whenever possible, over grass-covered ground and in an open area where free



① Front view of box. ② End view of box.



③ Front view of support. ④ End view of support.

FIGURE 2.—Specifications of instrument shelter.

air movement may be expected. The floor of the shelter should be approximately 4 feet above the ground. The location should be conveniently accessible to the observer.

(2) If such a location as described above is not obtainable, the

shelter may be installed on the roof, or secured to the north wall of a building. When the shelter is to be mounted on the wall of a building, it should be held a few inches away from the wall by attaching the shelter to thick strips of wood which have been previously bolted to the wall. Such an arrangement will permit free circulation of air between the wall and the shelter. Such installations, however, should not be made on buildings that are subject to considerable vibrations, because of the tendency for such vibrations to displace the index of the minimum thermometer.

(3) If the shelter is mounted over ground, the support legs must be bolted securely to buried timber members to insure against damage by high winds. Installations on the roof or wall of a building must likewise be made secure to prevent possible damage by high winds.

(4) In all cases the position of the shelter must be such that the door opens to the north, in order to insure greatest possible protection from direct radiation from the sun during the time when the instrument shelter door must be open.

d. Care.—About the only care necessary for proper maintenance of instrument shelters is to keep a clean coat of white paint over all surfaces, both outside and inside, maintain the inside free of dust by occasional dusting with a dry cloth, and inspect the mounting to insure that the shelter is secure against possible damage by strong wind force.

2. Townsend support.—*a. Purpose.*—The Townsend support is used to provide a suitable mounting for the maximum and minimum thermometers as these are exposed within the instrument shelter. It also provides a means by which these two thermometers may be "set."

b. Description.—(1) Sketches of a Townsend support, front view and side view, are shown in figure 3. The support consists of a metal base plate ⅛ inch thick, 2 inches wide, and 3 inches high. Carriers for the minimum and maximum thermometers are attached to this base plate.

(2) The carrier for the minimum thermometer is attached to the upper right side of the plate. This carrier consists of a frame, open at the left and right sides, into which the thermometer, with its metal back support, is placed so that the top and bottom lips of the frame hold the thermometer firmly as the setscrew is tightened from the back. This carrier is attached to the short projection stud, as shown in figure 3②, and through operation of the stop slot and stop pin can be rotated clockwise through approximately 90°. A small oil hole is provided near the base of the short projection stud, on the left side.

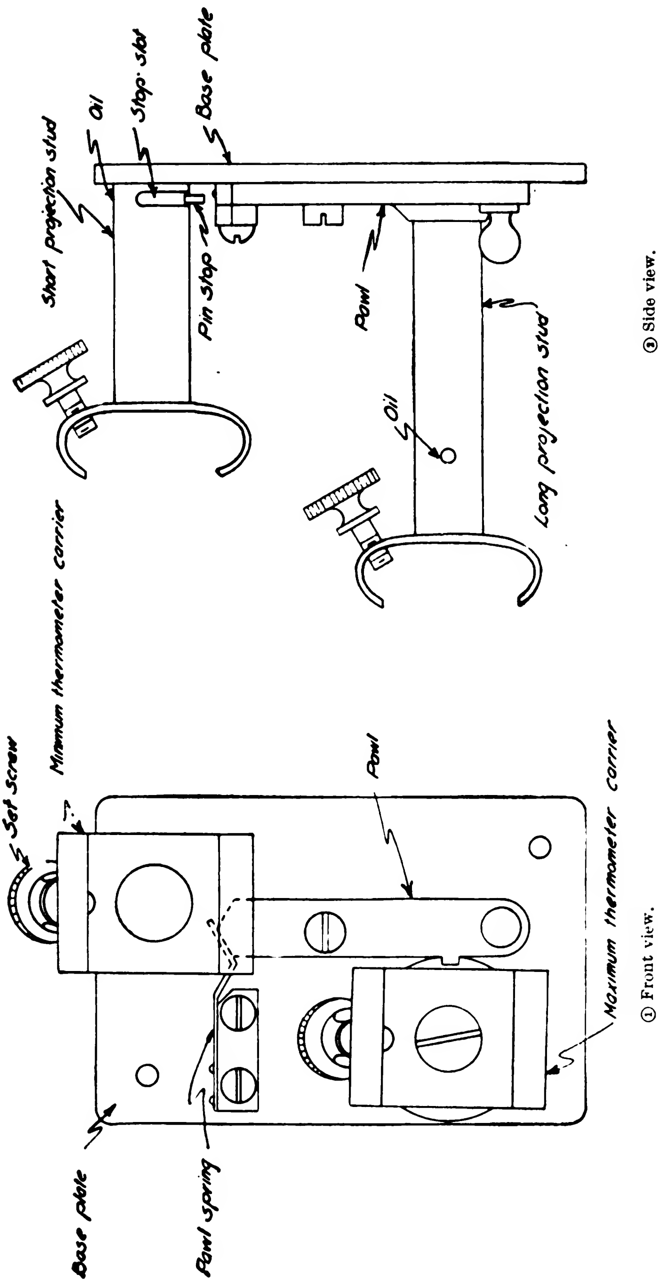


FIGURE 3.—Townsend support.

(3) The carrier for the maximum thermometer is attached to the lower left side of the plate. It is constructed in the same manner as the minimum-thermometer carrier and is attached to the long projection stud. This stud has a small notch cut from its base, into which a small projection of the pawl fits. This is shown engaged in figure 3①. The pawl is held in place by the pawl spring. A small oil hole is provided near the front of the long projection stud, on the right side.

(4) Figure 3① shows the position of the two carriers for holding the maximum and minimum thermometers while these two instruments are in operation. Both thermometers are held in a nearly horizontal position with their bulb ends to the left. After the minimum thermometer has been read, this instrument is "set" by rotating the carrier and short projection stud clockwise as far as it will turn. The stop pin will permit rotation through only approximately 90°. This brings the bulb end uppermost and the instrument is thereby "set", as will be explained more fully in that paragraph which describes the minimum thermometer. Then the carrier is rotated counterclockwise as far as the slot and pin will permit, and the instrument is then in its operating position.

(5) In order to prepare the maximum thermometer for a reading, the bulb end must be lowered so that the instrument rests in a vertical position. To do this the lower end of the pawl is pulled to the right, against the pawl spring, until the small projection is freed from the notch in the base of the long projection stud. This long projection stud is now rotated slowly and carefully counterclockwise until the maximum thermometer rests in a vertical position with the bulb end at the bottom. After the reading has been made, this instrument is "set" by whirling it rapidly. There is no stop pin on the long projection stud, so it is free to rotate through a full circle. After the maximum thermometer has been "set", it is brought to the operating position by reengaging the pawl and the long projection stud.

c. Installation.—The Townsend support is screwed firmly to the cross board of the instrument shelter, approximately in the middle. It should be mounted so that the long projection stud is at the bottom. The support properly installed, without the thermometers installed, is shown in figure 4.

d. Care.—The Townsend support seldom develops any defects and it will require but little care. A small drop of nonfreezing oil should be placed in the oil holes of the two projection studs once a month. The long projection stud is subject to somewhat more wear, due to the necessity of rotating the maximum thermometer several times during

each observation, but it will seldom require any special care. However, it is detachable in the event a replacement is necessary.

3. Thermometer.—*a. Purpose.*—The thermometer referred to in this paragraph is the ordinary mercury-in-glass thermometer which is

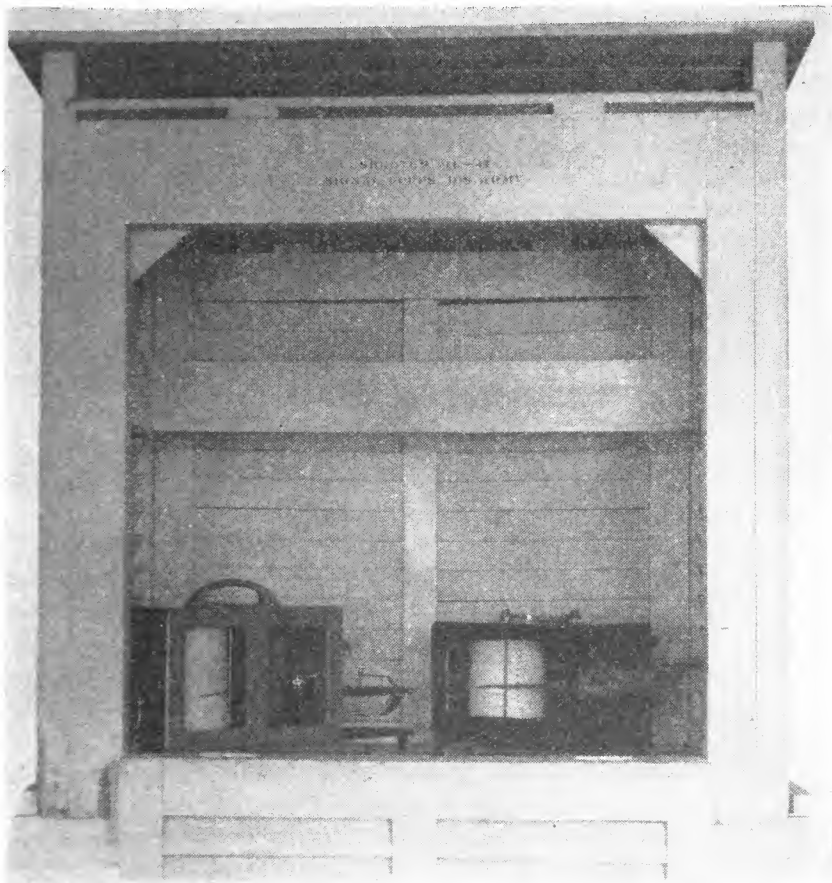


FIGURE 4.—Instrument shelter open.

used in surface meteorological observations to determine the temperature of the free air.

b. Description.—Surface free-air temperature is usually measured by a mercury-in-glass thermometer (fig. 5).

(1) It consists of a glass stem, approximately 10 inches in length, through which runs a central channel, commonly called the bore. The glass stem is about 0.250 inch in diameter. The bore is elliptical

in shape with the major axis 0.0095 inch and the minor axis 0.0045 inch. The bore opens into a cylindrical-shaped bulb. The outer diameter of the bulb is only slightly larger than that of the stem. The inner diameter of the bulb is 0.148 inch. Two hundred and thirty-nine thousandths (0.239) cubic centimeter of mercury is sufficient for the standard thermometer used to measure surface free-air temperatures.

(2) Graduations for each degree are placed both on the glass stem and on the aluminum support. For use in temperate climates, the graduations should read from —30° F. to 120° F. In hot climates an extension of the range up to 140° F. is necessary. Owing to the fact that mercury freezes at —39° F., the mercury thermometer is unsuitable for use in cold climates where temperatures of —39° F., and below, are expected. Instead, in such cold climates, thermometers filled with ethyl alcohol are used. These can be used for temperatures

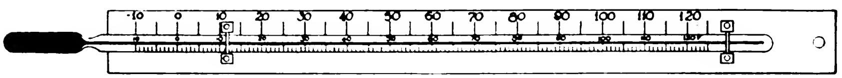


FIGURE 5.—Mercury thermometer.

down to —130° F., which is 40° F. below the lowest free-air tempera ture ever recorded on the earth's surface.

(3) Thermometers used for indicating current surface free-air temperature are always made with cylindrical bulbs because they are required to be quick acting and sensitive to the environment and medium in which they are exposed. A cylindrical-shaped bulb provides a greater surface for a given mass of contained mercury than does a spherical shaped bulb and, hence, will adjust itself to the temperature of the air more quickly.

(4) The top end of the stem is made with a small projection of glass on the rear side which fits into a hole near the top of the aluminum back and serves to hold the thermometer in proper position with respect to the aluminum support. Two small brass straps also serve to hold the thermometer to its support. Both the stem of the thermometer and the metal support are provided with degree graduations. If the thermometer proper remains correctly adjusted to the support, either set of graduations may be used in obtaining a reading. However, due to the chance of slight displacements of the thermometer with respect to the aluminum support, it is always better practice to take a reading from the graduations of the stem.

(5) It is customary to observe surface free-air temperatures to 0.10° F. To provide for such readings, the thermometer scale must be

sufficiently open. Approximately eighteen 1° divisions are contained within an inch. To assist further in accurate reading, a strip of white glass is provided the full length of the stem, on the rear side of the bore. This white glass serves as a good background against which the fine thread of mercury in the bore can be seen readily. Figure 6 represents a cross section of a thermometer stem and shows the relative position

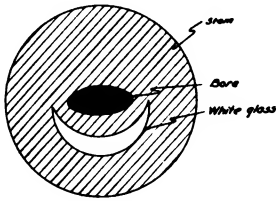
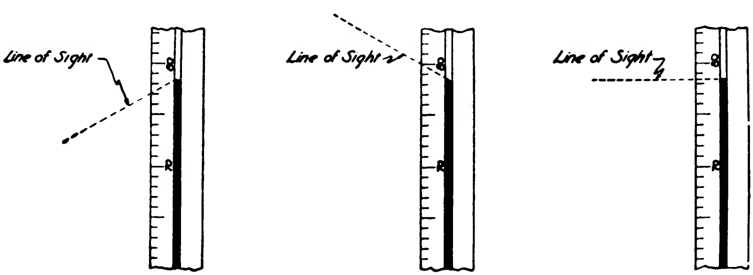


FIGURE 6.—Cross section of thermometer stem.

of the white glass. In cross section, it appears as a crescent-shaped area. It can be seen readily that to realize the benefit of the white glass background, the observer must stand directly in front of the thermometer while making a reading.

c. *Reading.*—(1) To accomplish surface free-air temperature readings accurately to the nearest 0.1° F., the observer must stand directly in front of the thermometer and adjust his position so that his line of sight is perpendicular to the stem of the thermometer at the top of the column of mercury. If his line of sight is not so adjusted, an error of parallax will be introduced which may amount to as much as 1° F.



① Observer's eye too low (reading 77.0°). ② Observer's eye too high (reading 80.0°). ③ Observer's eye in correct position (reading 78.4°).

FIGURE 7.—Error of parallax.

In figure 7① and②, the observer's line of sight is not perpendicular to the column of mercury at the top of the column. Under conditions shown at ① the reading would be too low, while under conditions shown at ② the reading would be too high. Figure 7③ shows the correct relation of the line of sight to the thermometer stem for an accurate reading.

(2) Thermometers should be read as rapidly as possible, consistent with accuracy, in order to minimize effects of the proximity of the observer and of radiation from surrounding objects.

(3) Due to difficulties encountered in the manufacturing of thermometers and inherent differences in the coefficients of expansion of mercury and of glass, thermometers are commonly found to show errors in their readings at various points along the scale. The manufacturer of a good thermometer always furnishes a table of corrections for each instrument. This table should be posted conveniently in the office of the weather station or placed inside the instrument shelter. Corrections for instrumental error must be applied to the mercury-in-glass thermometer, used for surface free-air temperature, whenever the temperature indicated by the thermometer is above 42° F. and the correction is plus or minus 0.3° or more, and whenever the indicated temperature is 42° F. or less.

d. Installation.—The thermometer used for surface free-air temperature readings is exposed in the instrument shelter, usually by hanging from a hook on the cross board. This thermometer is usually mounted on a combination aluminum back with the wet-bulb thermometer. Together, these two thermometers, with their associated provision for proper ventilation, make up what is called a psychrometer. The psychrometer will be discussed in a later paragraph.

e. Care.—(1) The thermometer must always be kept so that no deposit of dust or any foreign matter is allowed to accumulate on the bulb.

(2) During rain or snow storms which are accompanied by strong winds, sometimes the bulb of the thermometer will become wet, due to rain or snow having been driven through the louvered sides or through the slotted bottom of the instrument shelter. Also, if precipitation is occurring during the time that the instrument shelter door is open, the bulb of the thermometer may become wet. Presence of moisture on the bulb of the thermometer will cause it to indicate too low a temperature. If, for any reason, moisture is observed on the bulb, it should be wiped off carefully 10 or 15 minutes before a reading is taken.

(3) The aluminum back upon which the thermometer proper is mounted will frequently be observed to be partially covered with numerous rough gray spots. Although this condition does not affect operation and use of the thermometer, it does give it an unsatisfactory appearance, and the metal back should be cleaned to remove these spots at intervals of about 3 months. These gray spots are caused by oxidation of the aluminum. They can be removed readily by rubbing

with a soft cloth which has been soaked in a solution of sodium bicarbonate (ordinary baking soda). Under no circumstances should abrasives or acid solutions be used to clean the aluminum backs. In order to prepare the backs for proper cleaning, the thermometer proper should be separated from the metal back by removing the two brass straps. With the thermometer removed, the back can be thoroughly cleaned without danger of injury to the thermometer. While the brass straps are removed, they should be polished with metal polish. Upon reassembly, the four brass screws, used for holding the two straps, should have a very small amount of light oil applied to their threads.

(4) The principal trouble which develops through use of the thermometer is that the black material which is imbedded in the graduations on the aluminum back and on the stem drops out over different areas and thereby makes reading difficult. The graduations can be

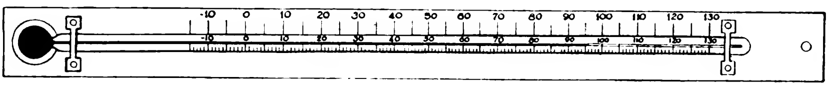


FIGURE 8.—Maximum thermometer.

renewed easily by application of a small quantity of artist's black pigment (ivory black). To renew the graduations, the thermometer should be removed from its aluminum support. Both support and thermometer should be carefully cleaned and dried. The older remaining pigment need not be removed. Then a small amount of fresh pigment, which is usually supplied in paste form, is placed on the stem and on the metal back. This can be applied readily by use of a match stick, rubbing up and down the full length of the stem and the metal back. Excess of pigment may be removed by rubbing over the parts of the thermometer lightly with soft tissue paper. The thermometer is now ready for reassembly on its mounting.

4. Maximum thermometer.—*a. Purpose.*—The purpose of the maximum thermometer is to indicate the highest temperature occurring at the place of exposure between the time of last setting and the time of reading.

b. Description.—(1) The maximum thermometer is usually a mercury-in-glass instrument. It consists of a stem and bulb, mounted on an aluminum back in a manner similar to that described under paragraph 3. (See fig. 8.)

(2) About the only outward appearing difference between this instrument and the ordinary thermometer is that the maximum thermometer has a spherical bulb. There are other important dif-

ferences which will be discussed in detail later. A spherical bulb is permissible for the maximum thermometer because this instrument is not required to be quick acting and sensitive to small changes in the temperature of the air. On the other hand, a relatively large volume of mercury is desirable. These features are both provided by the spherical bulb.

(3) The bore of the maximum thermometer is elliptical in shape and has the same dimensions as the bore of the ordinary mercury-in-glass thermometer. The bulb has an outside diameter of 0.432 inch, and an inside diameter of 0.428 inch. Approximately 0.60 cubic centimeter of mercury is used in this thermometer. A strip of white glass is provided in the stem of the maximum thermometer in the same manner as that described for the ordinary mercury-in-glass thermometer. Maximum thermometers are filled with mercury at a temperature nearly equal to the highest the given instrument can

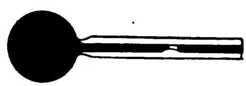


FIGURE 9.—Constriction in bore of maximum thermometer.

experience so that the space above the column at lower temperatures may be free of air.

(4) The principal structural feature of the maximum thermometer, which permits it to perform its function of indicating the highest temperature between times of setting and reading, is a constriction in the bore which is placed about seven-eights inch above the bulb. Upon close inspection this constriction can be seen plainly with the naked eye. As the temperature rises, the mercury in the bulb expands and is forced to move along the bore to the constriction. Further expansion forces the mercury into the constriction and to that part where the channel is narrowest. This is shown in figure 10①. At this point in the constricture, where the radius of curvature is smallest, cohesive forces within the mercury are greatest, and the result is that a small globule of mercury separates itself from the main body, which is in the stem and bulb below the constriction, and moves into the area above the constriction in a sudden, quick spurt. The position of a separated globule is shown by figure 10②. Continued expansion of the mercury in the bulb will result in a succession of separating globules which are forced up to join the main column in the upper bore. A close inspection of this part of the thermometer during a period of rising temperature will show this process of operation plainly visible to the naked eye. Thus with increasing tem-

perature some of the mercury is forced through the constriction to join the thread of mercury in the main part of the bore. As the temperature lowers, the mercury below the constriction, contracting as it cools, withdraws toward the bulb, but none of the mercury above the constriction can return. The length of the thread of mercury above the constriction remains the same as it was when the bulb was warmest. In this manner the maximum temperature is indicated at a reading made at any later time prior to occurrence of a higher temperature.

(5) If the thermometer is held in a horizontal position and then alternately tilted, first with the bulb end higher than the stem, then with the bulb lower than the stem, it will be observed that the thread of mercury may be made to flow to either end of the tube. But the length of this thread of mercury remains the same unless we drop the

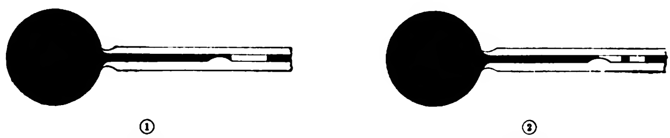


FIGURE 10.—Mercury passing through the constriction.

bulb end down suddenly. If this should happen, the weight of the mercury in the stem, together with the centrifugal force created by the quick motion of the bulb downward, will cause some of the mercury in the stem to be forced downward through the constriction, thus altering the length of the thread of mercury. Therefore, if we are to secure a reliable reading of maximum temperature, the thermometer must be handled carefully.

c. Installation.—The maximum thermometer is exposed in the instrument shelter and is mounted in the maximum-thermometer carrier of the Townsend support. This carrier, as shown in figure 3, is mounted on the long projection stud. The thermometer should be clamped into its carrier just below the upper brass strap, with the bulb end to the left. Figure 11 shows the maximum thermometer properly mounted on the Townsend support. Note that the bulb end rests about 5 degrees above the horizontal. It is mounted with the bulb end slightly elevated in order to insure that no part of the mercury that has once been forced through the constriction, and into the bore above, can return to the bulb upon a lowering of the temperature and before the thermometer is set.

d. Reading.—The maximum thermometer must be lowered carefully to a vertical position, with the bulb end downward, before read-

ing. The reading is then taken from the top of the mercury column in the stem, recording the value to the nearest 0.1° F. If the thermometer is not lowered carefully, but allowed to fall suddenly to a vertical position, some of the mercury will be forced from the bore of the stem through the constriction, and the reading will be too low. In order to prepare this instrument properly for reading, both hands should be used. Lightly grasp the aluminum back, about midway along its length, between the thumb and first two fingers of the left hand. Then release the pawl with the right hand, and lower the thermometer carefully to a vertical position with the left hand. Greater care must be used during periods of high maximum temperatures because of the greater weight of the long column of mercury.

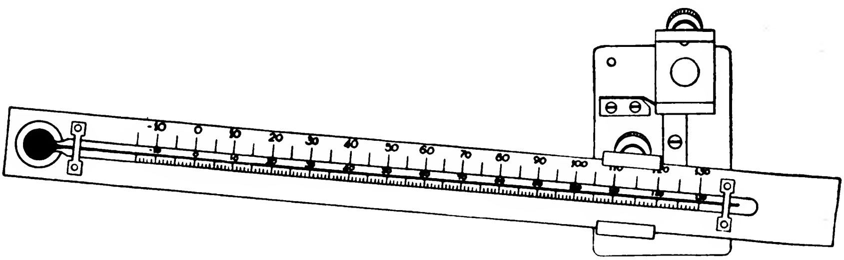


FIGURE 11.—Maximum thermometer in operating position.

e. Setting.—After the reading and recording of maximum temperature, the instrument must be prepared for the operation of indicating the highest intervening temperature between the time of current reading and the next reading to be taken. This preparation of the maximum thermometer is called "setting" it. Under paragraph 2*b*, it was explained that the carrier for the maximum thermometer was fixed to the long projection stud of the Townsend support and that this stud was free to rotate through a complete circle. To "set" this thermometer, place a finger or pencil along the left side of the thermometer scale near the top, and impart to it a rapid clockwise rotation. Allow the thermometer to whirl until it comes to rest itself. Do not try to stop it while whirling. Repeat the whirling, if necessary, until the column of mercury in the stem has been forced down as far as it will go. When setting is complete, the top of the mercury column should read the same as in the dry-bulb thermometer, within the limits of instrumental errors of the instruments concerned. Next, engage the pawl and carefully elevate the bulb end of the thermometer until the pawl catches and holds the carrier. The thermometer is now "set" and ready to indicate the ensuing maximum temperature.

f. Care.—(1) Methods of cleaning the metal back of the maximum thermometer and renewing the graduations are the same as described in paragraph 3*e*(3) and (4) for the dry-bulb thermometer.

(2) The space in the bore of the tube not occupied by mercury is a vacuum. If mercury does not rest upon the constriction before the operation of whirling is started, incident to "setting", the violent throw-down of mercury may fracture the constriction and leave it much larger than it should be. When such internal fracture has occurred, it will be apparent as an iridescent patch in the neighborhood of the constriction when the thermometer is examined in reflected light. The instrument is then defective and is said to be a "retreater." The constriction is now so large that, as the temperature lowers, some of the mercury from the bore above will retreat through the constriction into the bulb. Also, even with careful lowering of the instrument prior to reading, a "retreater" will permit some of the mercury in the upper stem to pass through the constriction. Obviously, accurate

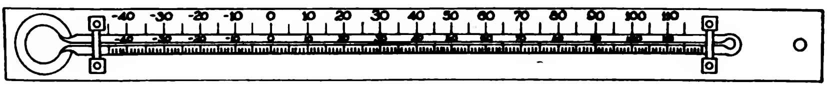


FIGURE 12.—Minimum thermometer.

maximum temperatures cannot be obtained from such instruments. As soon as a "retreater" is discovered, it should be replaced with a serviceable instrument.

5. Minimum thermometer.—*a. Purpose.*—The purpose of the minimum thermometer is to indicate the lowest temperature occurring at the place of exposure between the time of last setting and the time of reading.

b. Description.—(1) The minimum thermometer is an alcohol-in-glass thermometer. It consists of a stem and bulb, mounted on an aluminum back in a manner similar to that previously described for the dry-bulb thermometer and for the maximum thermometer. A sketch of a minimum thermometer is shown in figure 12. This thermometer employs the use of uncolored ethyl alcohol instead of mercury. It has a spherical bulb as does the maximum thermometer.

(2) In the construction of minimum thermometers, the upper part of the bore is filled with air under pressure. The purpose of air pressure in the upper part of the bore is to prevent evaporation of the alcohol and formation of alcohol vapor which would later condense and form detached segments of alcohol, thus rendering the instrument unserviceable. If part of the alcohol from the bulb and lower part of

the bore were permitted to evaporate, the readings obtained would be too low. This will be explained later.

(3) Figure 13 shows a cross section of the stem of a minimum thermometer. The bore of this thermometer is a circular disk in cross section, 0.021 inch in diameter. This is considerably larger than the bore of the maximum or ordinary mercury-in-glass thermometer. This is necessary to provide space for the glass index. The bore of the minimum thermometer is terminated, at its upper end, in

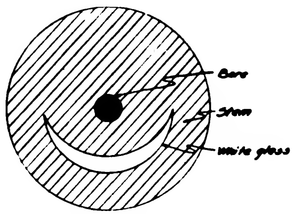


FIGURE 13.—Cross section of stem of minimum thermometer.

an enlarged space, somewhat pear-shaped. As the temperature rises, not only does the pressure of the air increase due to its higher temperature, but the alcohol rises in the bore, reducing the space available to the air and thereby increasing its pressure. The comparatively large volume of this enlarged space at the top of the stem permits volume decrease, due to movement of the alcohol upward through the relatively small bore, without undue increase in the internal pressure. The decrease in air space through the bore is so small when compared to

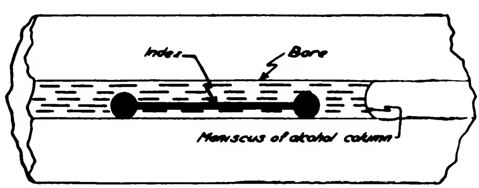


FIGURE 14.—Section of stem of minimum thermometer.

the total volume, including the pear-shaped space, that the increase in pressure is not injurious to the instrument.

(4) An important feature of the minimum thermometer is the colored glass index, which is shown in the upper part of the stem in figure 12. Figure 14 is an enlarged drawing of a section of the stem of a minimum thermometer, showing the bore, the meniscus of the alcohol column and the index. The index is a dumbbell-shaped piece of black glass, about nine-sixteenths inch in length, or about long enough to extend over 10° divisions of the thermometer scale. The index is

made in this particular form so that it will provide a relatively large surface of contact with the surface of the alcohol column, while at the same time the main shaft of the index is very small, thus making the mass as small as possible. The index rests on the bottom of the bore on only the lower surfaces of the two rounded ends, thereby reducing friction incident to its motion along the bore to a minimum. In the operating position, this thermometer always rests in a horizontal position, with the bulb end to the left. As the temperature increases, the alcohol expands and flows around the index, without disturbing it. In figure 14, the top of the alcohol column is shown some distance to the right of the index.

(5) Figure 15 shows the alcohol having retreated toward the left, with a decrease in temperature, until the top surface of the column is just touching the right-hand end of the index. Any further cooling will cause the alcohol to move farther to the left. As this occurs,

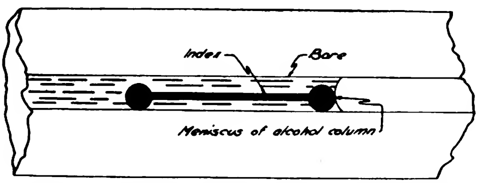


FIGURE 15.—Section of stem of minimum thermometer.

cohesion of the alcohol molecules on the top surface prevents the index breaking through this surface of the alcohol, and it is thereby drawn to the left along with the alcohol. As long as the temperature continues to decrease, the index will continue to be displaced to the left. After the lowest temperature has been reached, the alcohol will begin again to flow to the right but will leave the index resting at its farthest point of displacement to the left, which is toward the bulb end of the instrument and lower indicated temperatures. The top of the alcohol column always indicates the current temperature, so the right-hand end of the index should indicate the lowest temperature experienced by the instrument between the times of last setting and of reading. Approximately 0.62 cubic centimeter of alcohol is used in a minimum thermometer of this type.

c. *Installation.*—The minimum thermometer is exposed in the instrument shelter and is mounted in the minimum-thermometer carrier of the Townsend support. This carrier, as shown in figure 3, is mounted on the short projection stud. The thermometer should be clamped into its carrier about midway along the aluminum back support, with the bulb end to the left. Figure 16 shows the minimum

thermometer properly mounted on the Townsend support. When in set position the thermometer is placed with the bulb end about 5° below the horizontal.

d. Reading.—The minimum thermometer is read while it is in the set or nearly horizontal position. The reading is taken from the position of the right-hand end of the index, recording the value to the nearest 0.10° Fahrenheit.

e. Setting.—(1) After a reading and recording of minimum temperature, the instrument must be prepared for the operation of indicating the lowest intervening temperature between the time of the current reading and the next reading to be taken. This preparation of the minimum thermometer is called "setting" it. Under paragraph 2 *b*, it was explained that the carrier for the minimum thermometer was fixed to the short projection stud of the Townsend support, and

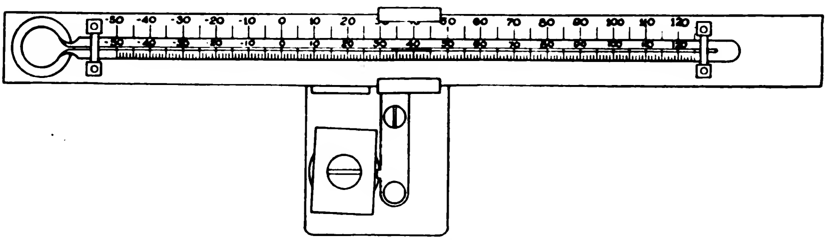


FIGURE 16.—Minimum thermometer in operating position.

that this stud can be rotated so as to bring the minimum thermometer from its nearly horizontal (operating) position, clockwise through 90° to a vertical position with the bulb end uppermost.

(2) Figure 17 shows the minimum thermometer in the inverted position. The stop pin on the short projection stud of the Townsend support prevents the instrument being rotated farther than to the inverted position. In this position the index falls, due to its own weight, to the head of the alcohol column. The surface tension of the alcohol prevents the index penetrating the surface. The instrument is next rotated counterclockwise to the horizontal position, and the operation of "setting" is completed.

f. Care.—(1) Methods of cleaning the metal back of the minimum thermometer and renewing the graduations are the same as described in paragraph 3*e*(3) and (4) for the dry-bulb thermometer.

(2) Minimum thermometers often become temporarily unserviceable, due to the alcohol in the bore of the stem becoming separated into several short, detached segments. This separation may occur as the result of exceptionally rough handling in shipment, or due to

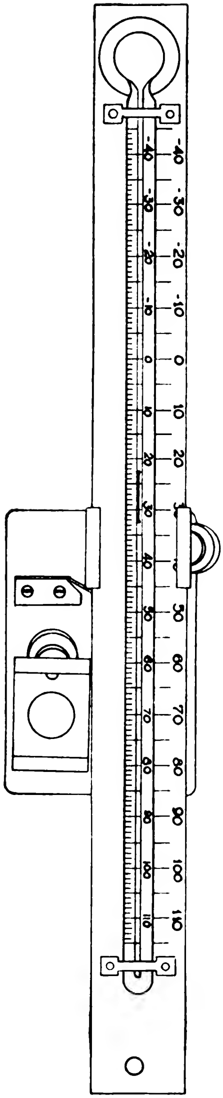


FIGURE 17.—Minimum thermometer inverted for "setting."

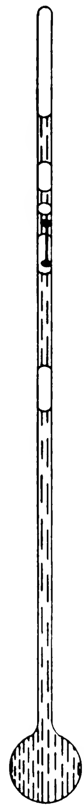


FIGURE 18.—Minimum thermometer with index held by broken segments of alcohol column.

distillation of alcohol from the lower part of the bore and its collection in segments in the upper part. If the defect occurs as a result of excessive jarring, such as might take place in shipment, it is usually found that the alcohol column is broken into several short segments through most of the length of the bore. Such a condition is shown in figure 18. In this figure it is to be noted that the index has been caught and held by two segments of alcohol. This represents the most complete separation of the column and is the most difficult condition to correct.

(*a*) The first step in the operation of bringing such a thermometer again to a serviceable condition is to get the index into the bulb. The most effective means of doing this is to hold the thermometer lightly between the thumb and fingers and strike the lower end of

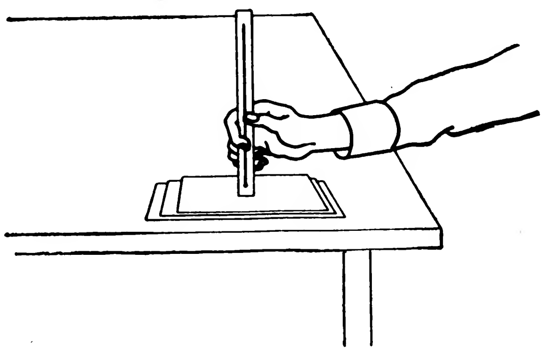


FIGURE 19.—Dislodging index of minimum thermometer from detached segments of alcohol column.

the metal back support against the top of a table or other firm object' as shown in figure 19. It is well to interpose one or two thicknesses of cloth or several folds of paper so that the impact will not produce too severe a shock upon the thermometer. The striking should be made lightly at first and the thermometer examined to see if the index has not moved along the tube even a little distance, as can be determined by noting its exact position in reference to the graduations of the tube. If several operations fail to move the index, gradually increase the force with which the thermometer strikes the table, until the index is dislodged and enters the continuous column. From this position it will fall of its own weight into the bulb.

(*b*) Incident to efforts to dislodge the index as just described, most of the detached segments of alcohol will also have been partly or wholly united. If the column is still broken in places, the observer

should try a few more taps and examine quickly in a very careful manner. Small portions of the alcohol will generally be seen slowly moving along the sides of the tube toward the main column, and a continuation of the taps will unite all the segments to the column. In some cases 15 or 20 minutes may be required to unite broken columns completely. If, however, the index cannot be made to move with quite hard striking, or the segments cannot be united, it is advisable to try some of the methods described below, being careful always to avoid continuing any process so long or so forcefully as to endanger breaking the thermometer.

(c) If the minimum thermometer is found to have only a small number of small segments in the upper part of the bore, this condition is probably due to distillation of some of the alcohol from the main column. In such cases, the index is usually not held within or between segments and the condition is more easily corrected. One method of uniting such small detached portions of the column is to grasp the thermometer securely a little below the middle, with the bulb end down, and strike the edge of the metal back, opposite the broken column, sharply against the fleshy portion of the palm of the other hand, or if necessary, against a small block of wood held in the hand. A continued jarring in this way often causes the alcohol to run down, though in many cases a large number of taps are necessary. Here, again, care must be exercised not to strike too hard, and to hold the thermometer by the metal back in such a manner as not to squeeze or press against the stem of the thermometer itself.

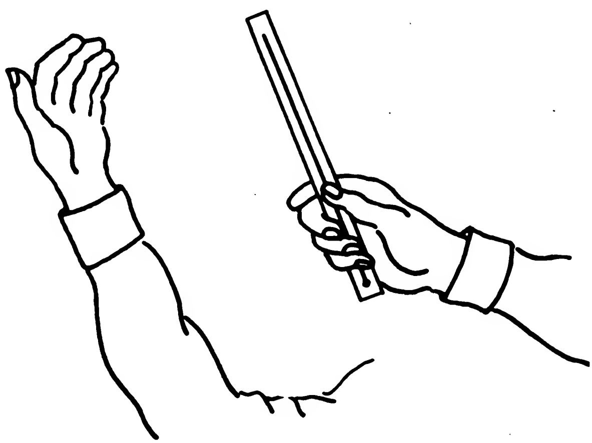


FIGURE 20.—Reuniting segments of alcohol column of minimum thermometer.

(*d*) Another method of uniting segments of the alcohol column is to grasp the thermometer a little above the middle, clasping the fingers and hand firmly against the edges of the metal back, but not so as to bring any pressure upon the glass tube, which should be turned toward the observer and with the bulb uppermost, as shown in figure 21. With the thermometer in this position and about as high as the head, and the arm free from the body, quickly lower the arm and hand through an arc of three or four feet, stopping the motion suddenly. Centrifugal force thereby developed will often be found to reunite segments of alcohol to the main column. This method is also sometimes effective in forcing the index into the bulb.

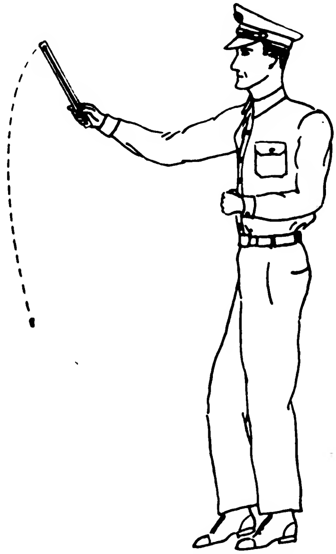


FIGURE 21.—Reuniting segments of alcohol column of minimum thermometer by centrifugal force.

(*e*) If none of the above methods is successful in forcing the index into the bulb and reuniting the segments of the alcohol column, the thermometer should be replaced by a serviceable instrument.

6. Wet-bulb thermometer.—*a. Purpose.*—The wet-bulb thermometer is employed, in connection with the ordinary or dry-bulb thermometer, to provide a measurement of the water vapor content of the air. From readings of the dry- and wet-bulb thermometers, and a knowledge of the atmospheric pressure, such reduced values as dew point, relative humidity, mixing ratio, specific humidity and vapor pressure may be computed.

b. Description.—(1) The wet-bulb thermometer is exactly similar to the ordinary thermometer, or dry-bulb thermometer, referred to in paragraph 3, except that the bulb is covered with a tightly fitting cloth cover. The cloth cover consists of white muslin, washed free of all sizing or starch. It is just long enough to extend about a quarter of an inch above and below the bulb of the thermometer. In its other dimension it is wide enough to wrap around the bulb once, only, and with about a one-third wrap overlap. Thus, for the ordinary sized bulb, the piece of muslin should be ¾ inch by 1¼ inches.

(2) When placing the cloth covering about the bulb it is best to wet the muslin first. This will permit it to be wrapped tightly about the bulb, and also it will adhere to the glass while the operation of tying at the upper and lower ends is completed. First place the thermometer on a flat surface, such as a book, with the bulb end of the thermometer extending over one edge of the book, as shown in figure 23①. Place the wet muslin, cut to proper size, under the bulb, with approximately one-quarter inch extending above and below the bulb, as

FIGURE 22.—Wet-bulb thermometer.

shown in figure 23②. Wrap the muslin tightly about the bulb, being careful to leave the proper amount of cloth above and below the bulb. This condition is shown in figure 23③. With a short piece of fine, strong white thread, tie the cloth about the narrow part of the stem, immediately above the bulb, as shown in figure 23④. Next, loop another piece of thread about the lower end of the bulb, as shown in ⑤, making certain that the thread is about one-quarter inch to one-eighth inch above the lower end of the bulb. Tighten the thread, as shown in ⑥. Further tightening of the knot will cause the loop of thread to slip slowly downward over the rounded lower end of the bulb while, at the same time, holding and tightening the cloth snugly to the bulb. Figure 22⑥ shows the lower knot just about to start slipping over the rounded end of the bulb, while ⑦ shows the knot completely tightened. Finish the knot and trim off the excess thread. The completed covering is shown in ⑧.

(3) Sometimes long tubes of wicking are furnished for wet-bulb coverings. When these are used, it is necessary only to cut off the proper length and tie above and below the bulb as previously described. This wicking is not as satisfactory as the flat piece of muslin because sizes of thermometer bulbs vary considerably and it is, therefore,

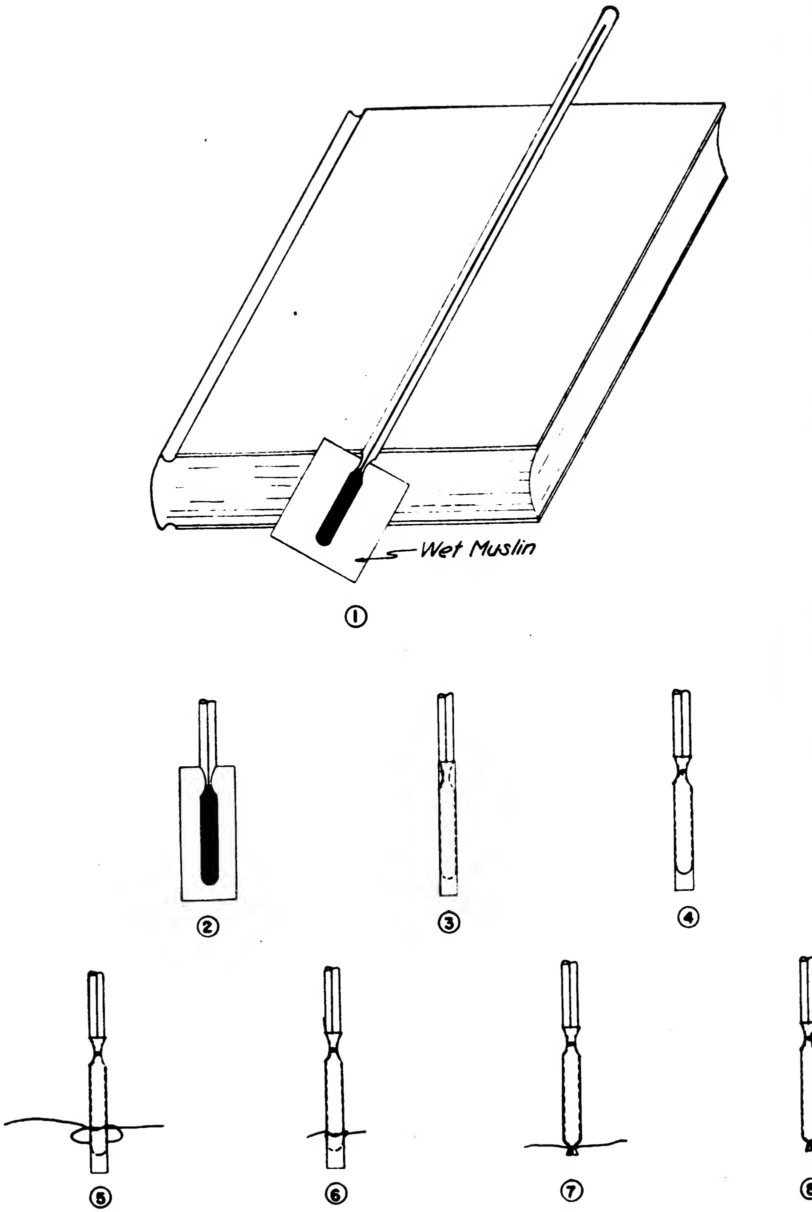


FIGURE 23.—Placing new muslin cover on wet-bulb thermometer.

sometimes impossible to make the wicking tube fit as snugly to the bulb as is desired.

c. Installation.—(1) The wet-bulb thermometer is installed in the instrument shelter and is usually mounted, in some manner, with the ordinary or dry-bulb thermometer. When mounted together, the arrangement of these two thermometers is called a psychrometer. The most easily portable and common type of mounting for dry- and wet-bulb thermometers is that shown in figure 24. This arrangement of the two thermometers is called the sling psychrometer. Note that the wet-bulb thermometer is mounted in such a manner on the common aluminum back that its bulb extends some distance below that of the dry-bulb thermometer. The instrument is supported in

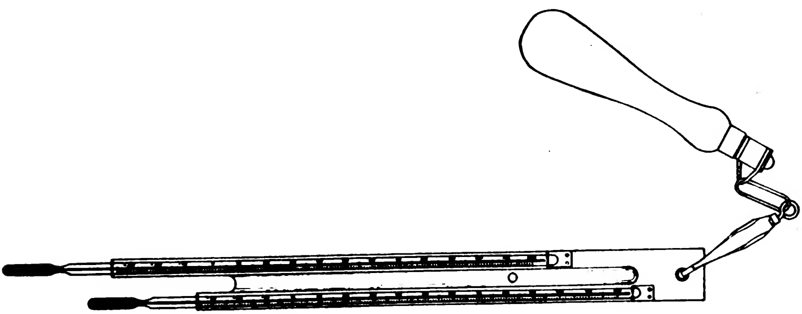


FIGURE 24.—Sling psychrometer.

the instrument shelter by hanging from a nail or hook placed in the right side of the vertical support of the cross board.

(2) A whirling psychrometer is shown in figure 25. In this arrangement, the two thermometers are whirled and ventilated by operation of the crank shown in the drawing. This type of psychrometer has the disadvantage that the operation of whirling the instrument causes vibrations of the other instruments mounted in the shelter, thereby affecting their operation.

(3) Sometimes the dry- and wet-bulb thermometers are ventilated by a fan mounted in the lower right inside of the instrument shelter and operated by a crank which extends through the right side of the shelter. Such an installation is shown in figure 26. This type is subject to the same objection as that offered for the whirling psychrometer, due to vibration caused by operating the crank to turn the fan.

(4) The sling psychrometer has the objection that it must be whirled outside the instrument shelter, and therefore subjects both ther-

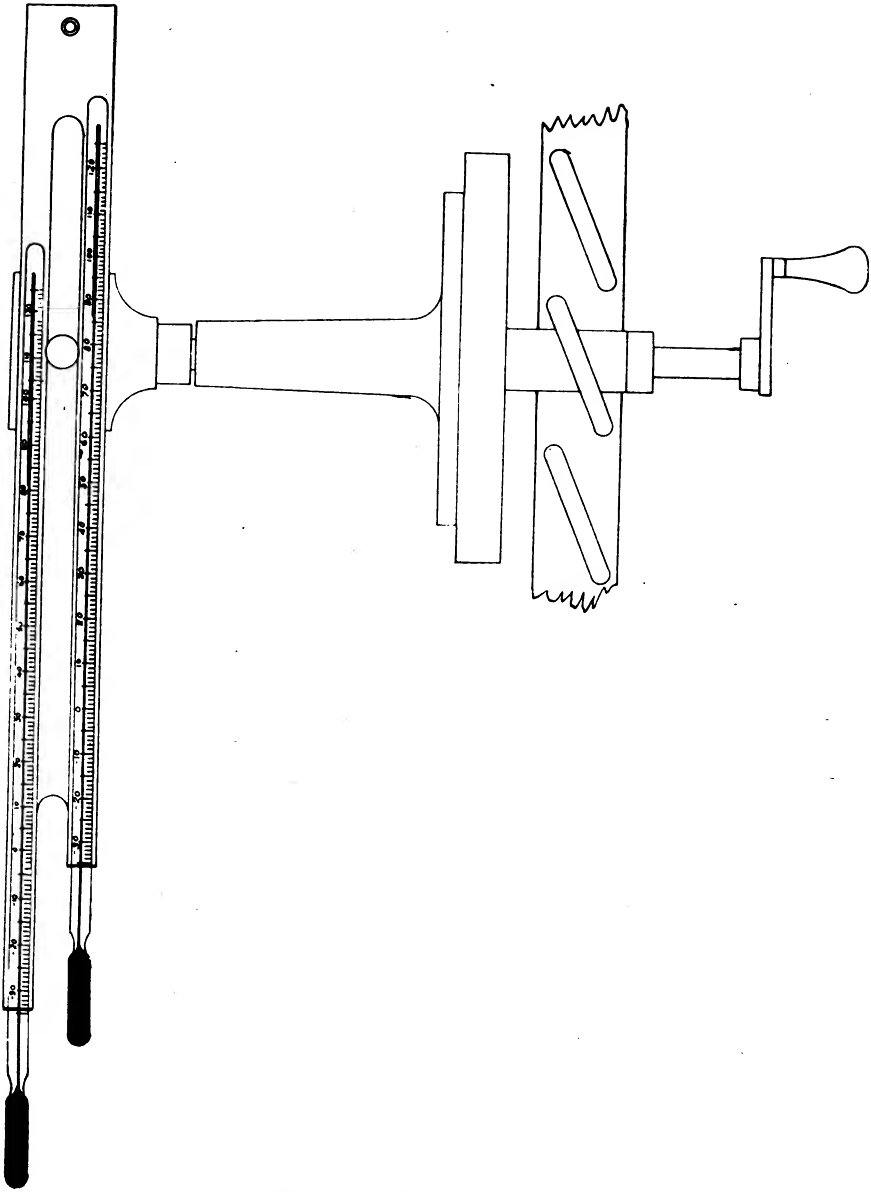


FIGURE 25.—Whirling psychrometer.

mometers to the effect of radiation. Also, during periods of precipitation, the operation of the sling psychrometer can hardly be protected to the extent that some snow or rain will not collect on the dry thermometer, thereby affecting the indicated air temperature by causing it to act as a wet bulb and indicate a lower than true temperature. However, by judicious and careful employment of the sling psychrometer, these disadvantages can be greatly minimized, and the portability of this type greatly outweighs its disadvantages. The sling psychrometer is used at nearly all Army Air Forces weather stations.

d. Reading.—(1) The wet-bulb thermometer is prepared for reading by wetting the cloth-covered bulb in clean water and then ventilating

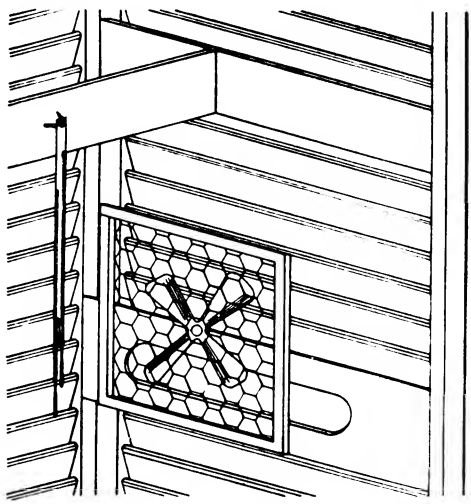


FIGURE 26.—Fan-ventilated psychrometer.

the instrument. Evaporation of water from the cloth covering is accomplished by heat which is withdrawn from the air immediately surrounding the thermometer bulb. Thus, as soon as evaporation starts, this thermometer will begin to show a lower temperature. The reading of this thermometer will continue to show a lower and lower temperature as long as the rate of evaporation from the wet bulb is increasing. When the rate of evaporation is greatest, the wet-bulb thermometer will show its lowest reading. This is the reading that should be recorded. Obviously, with the indicated reading changing as it does, in order to insure that the lowest reading is recorded several observations of this thermometer must be made. After the cloth covering has been wet, the instrument should be ventilated by what-

ever means are available. If a sling psychrometer is used, the observer whirls this instrument while standing with his back to the sun. After about 15 seconds of whirling, he reads the wet-bulb thermometer, being careful to hold the instrument in the shade of his body but not so close as to allow body heat to affect the reading. This reading is noted but not recorded. The whirling is continued and another reading is noted after about 10 seconds. If the reading is dropping rapidly, readings can be continued at intervals of 10 seconds. When succeeding readings become separated by only a degree, or less, they should be made at intervals not longer than 5 seconds. Finally, when continued ventilation causes no further lowering of indicated temperature from the wet-bulb thermometer, the lowest reading is recorded. All readings are made to the nearest 0.1° Fahrenheit.

(2) During freezing weather, the cloth covering of the bulb should be wetted 10 or 15 minutes prior to the scheduled time for observation. The reason for this precaution is that the water will freeze and thereby release the heat of fusion which will cause the reading to be too high. After about 10 minutes, this heat of fusion will have been lost by radiation. The thermometer may then be ventilated and evaporation from the ice on the cloth covering of the bulb will give a true reading.

(3) During conditions of high air temperature and low moisture content, special care must be used to insure that the cloth covering of the bulb does not become dry before the lowest possible wet-bulb temperature is reached. To guard against this, the cloth covering should be thoroughly wetted about 5 minutes before ventilation is started. In this manner, some lowering of the temperature will take place before the whirling is started. Then thoroughly wet the covering again and start the ventilation.

(4) If the air is saturated, a condition of 100 percent relative humidity exists, no evaporation from the wet bulb can occur, and the reading of this thermometer must be exactly the same as that of the dry-bulb thermometer. If the air is not saturated, the wet-bulb thermometer reading must always be lower than that of the dry-bulb.

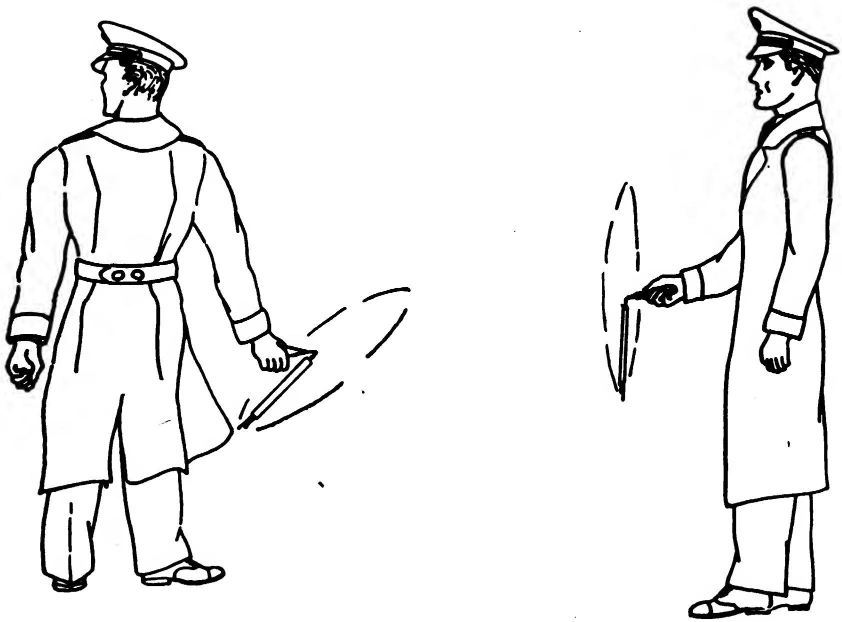
e. Care.—(1) Cleaning of the metal back of the wet-bulb thermometer and renewing of the graduations on the metal back and on the stem are accomplished in the same manner as that described for the ordinary, or dry-bulb thermometer in paragraph 3*e* (3) and (4).

(2) Many wet-bulb thermometers are broken as a result of carelessness in the operation of whirling the psychrometer. The damage usually occurs as a result of the psychrometer being whirled alongside of the body instead of in front of the observer where it can be

seen at all times. Figure 27 shows correct and incorrect methods of whirling the psychrometer.

(3) The small brass straps which hold the dry- and wet-bulb thermometers to the metal back support should be inspected frequently and kept securely fastened. If one or more of these straps becomes loose, the thermometer is liable to be thrown free and broken as the whirling is started.

(4) The cloth covering of the bulb must be replaced as often as necessary to maintain a covering that is free from dust and other foreign matter. No fixed time interval between renewals can be



① Incorrect. ② Correct.

FIGURE 27.—Whirling the sling psychrometer.

stated, as this is dependent upon the locality. At some stations near industrial areas, where a great amount of smoke and minute suspended oil droplets are present in the air, the cloth covering should be changed about once each week. In other areas the covering may remain reasonably clean for a period of 2 or 3 weeks. In no case should a covering for a wet-bulb thermometer be continued in use for longer than 1 month.

(5) Water for use on the wet-bulb thermometer must be clean. Preferably it should be distilled water or rain water, and so free of all mineral matter. It should be kept in a small wide-necked and

stoppered bottle. During freezing weather, this water supply must be removed from the instrument shelter and kept inside at nonfreezing temperatures.

7. Thermograph.—*a. Purpose.*—The thermograph is used to secure a continuous and automatic registration of temperatures.

b. Description.—(1) *General.*—Figure 28 shows a sketch of a thermograph, with its cover case removed. Principal parts and features of this instrument have been labeled. Detailed drawings of each part will follow. The actuating element of this thermograph is a closed curved tube of oblong cross section, which is filled with alcohol. This part of the instrument is known as the Bourdon tube. As the temperature changes, the change in volume of the liquid causes the curvature of the tube to be modified. By having one end of the tube fixed in position, while connecting the free end, through a system of linkages, to a tracing point, a continuous record of temperature changes and values is recorded on a moving surface. As the temperature increases, the Bourdon tube assumes a shape of larger radius of curvature. Since the right end of the tube is fixed, change in the radius of curvature means that the left, or free, end of the tube is lowered. An examination of the linkage connection to the pen arm shows that as the free end of the Bourdon tube is lowered, the pen arm, with tracing point, is moved upward, thereby recording a higher temperature. Conversely, as temperature decreases, the volume of the alcohol decreases and the tube assumes an arc shape of smaller radius of curvature. Thus the free end of the Bourdon tube rises and the pen arm and pen fall, thereby recording the lower temperature.

(2) *Clock unit.*—(*a*) The clock unit consists of a jeweled clock movement housed in a brass cylinder, the latter serving as a drum upon which the chart for receiving the temperature record is placed. Figure 29 shows several views of the clock unit. The clock construction is designed for outside use under changing and extreme weather conditions.

(*b*) Figure 29① shows a side view of the clock housing cylinder. Charts for receiving the temperature record are placed around this cylinder, with the bottom edge of the chart snugly fitted along the bottom flange. The spring clip shown in this drawing holds the two ends of the chart.

(*c*) Figure 29② shows a top view of the clock unit. The key for winding the clock is shown on the left while the regulator is shown on the right. In the older thermographs a knurled-headed screw was used to fasten the clock to the clock shaft. This no longer appears

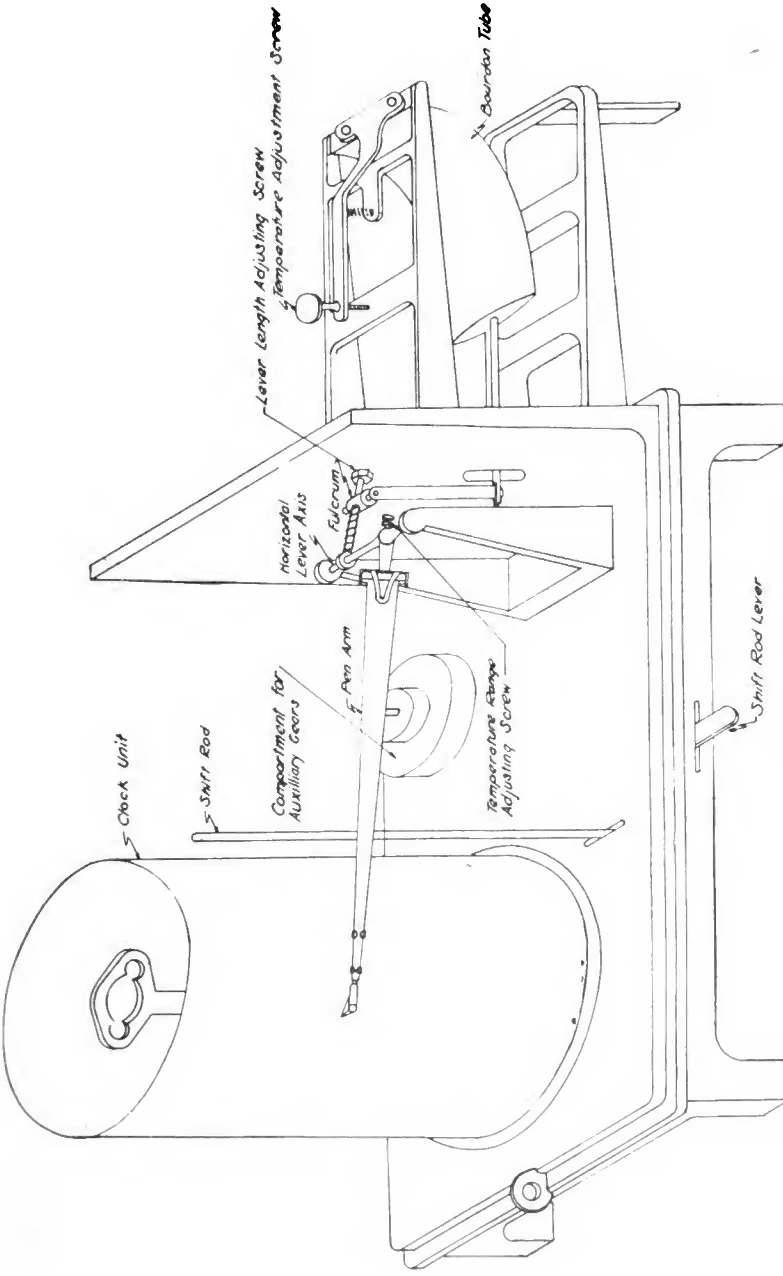
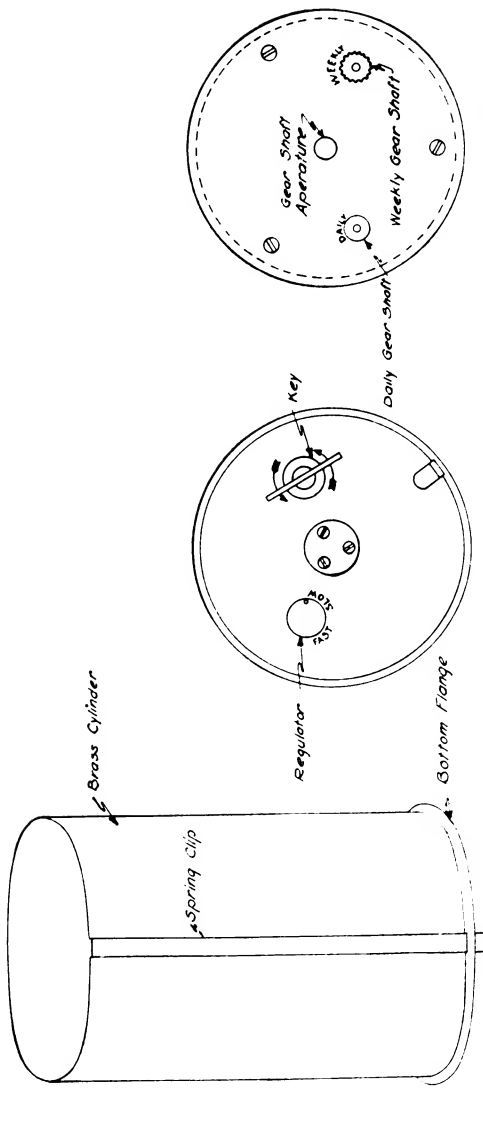


FIGURE 28.—Thermograph.



① Side view. ② Top view. ③ Bottom view.

FIGURE 29.—Clock unit of the thermograph.

in the newer instruments. In order to remove the clock housing it is now necessary only to lift the entire clock unit upward far enough to free the unit from the clock shaft.

(*d*) Figure 29③ shows a bottom view of the clock unit. Through the center is seen the aperture for the main clock shaft. (This main shaft is fastened to the base frame by a wing nut.) To the left and right of this aperture are shown shafts for the daily and weekly gear pinions, respectively. If it is desired that the cylinder rotate weekly the appropriate clock pinion is adjusted to the clock shaft and the proper gear pinion is fastened to the weekly gear shaft. Weekly pinions have the number "176" stamped on each, the number indicating the total number of hours required for a complete rotation of

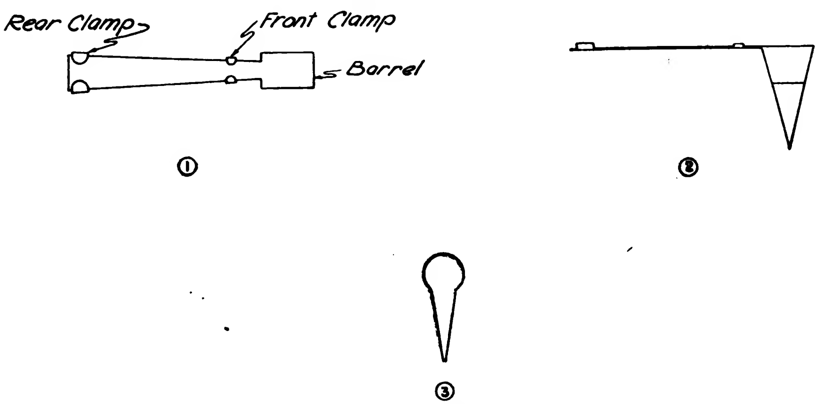


FIGURE 30.—Thermograph pen.

the cylinder. If it is desired that the cylinder rotate daily, another set of gear pinions is provided. Daily pinions have the number "29" stamped on the face of each. Normally, the thermograph is operated with one rotation of the cylinder each week. The extra gear pinions are kept in the compartment for auxiliary gears. This compartment is shown near the rear of the base stand in figure 28.

(3) *Pen.*—(*a*) The recording pen used on the thermograph is shown by the drawings of figure 30. This pen is made of nickel-silver. Top, side, and front views are shown in figure 30. The pen is adjusted to the pen arm by sliding it on so that the tip of the pen arm rests under the front and rear clamps of the pen, as shown in figure 30①. Usually there is a shoulder on the pen arm which prevents the pen being placed too far back on the arm. The clamps can be used to hold the pen firmly and to adjust the position of the pen so that the over-all length of the pen arm is proper.

(*b*) A front view of the pen barrel is shown in figure 30③. This barrel is partially filled with a special ink which contains a percentage of alcohol and glycerin to assure that it will remain liquid under conditions of low temperature. The flow of ink takes place from the reservoir of the barrel between the leaves of the barrel by capillarity as in any other pen. In order to start the flow of ink it is frequently necessary to run a piece of hard bond paper, of about chart thickness, between the leaves of the barrel.

(4) *Pen arm.*—(*a*) The pen arm of the thermograph is shown by the drawing of figure 31. The pen fits onto the spiked end of the pen arm, firmly against the shoulder. The length of the effective pen arm is important if the instrument is to record temperature values without error. The chart for receiving the record is designed, and other adjustments of the instrument are arranged, for best performance of the

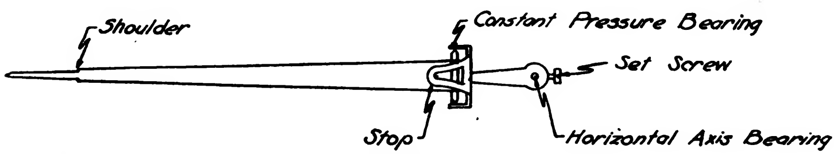


FIGURE 31.—Thermograph pen arm.

instrument when the length of the pen arm from the tip of the spiked end to the center of the horizontal axis is 14 centimeters, or 5.51 inches.

(*b*) The pen-arm carriage is held to the horizontal axis by the setscrew. This carriage is so fitted to the horizontal axis that the upright plane of the pen arm is tilted a few degrees inward at the top so as to throw the pen positively against the chart. The constant-pressure bearings insure proper pressure of the pen against the chart at all times. In the older thermographs an adjusting screw is provided near the base end of the pen arm for the purpose of adjusting the pen pressure to the proper value.

(*c*) The pen arm always rests outside the shift rod. During the process of changing charts, the shift-rod lever is used to lift the pen from the chart and far enough away from the drum to prevent damage while the sheet is being changed. When the pen is lifted from the chart the pen-arm stop prevents the arm swinging outward far enough to interfere with the observer while working on the instrument.

(5) *Lever-length adjustment.*—In addition to the provision for adjusting the length of the pen arm by a slight change in the position of the pen, the effective length of the lever can be modified by changing the position of the fulcrum. The horizontal axis and fulcrum assembly

are shown by the drawing of figure 32. The fulcrum, as shown in figure 32, can be adjusted in position by shifting to the right or left. It is held in position on the rod which extends to the right from the rear end of the horizontal axis. This rod is square in cross section throughout the greater part of its length, but has an interrupted thread cut into it on the right half of its length. The fulcrum is held in position on this rod both by the spring and the setscrew. If it is desired to shorten the effective pen arm, the fulcrum is moved to the left. To do this, it is only necessary to loosen the setscrew and turn the

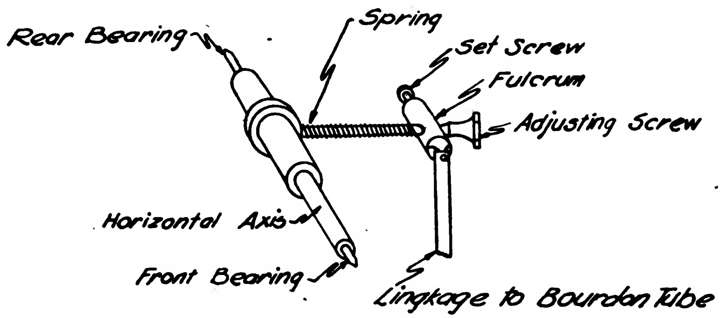


FIGURE 32.—Lever-length adjustment.

adjusting screw clockwise. After adjustment is completed, the setscrew is again tightened. If the pen arm is to be lengthened, the fulcrum is moved to the right. The attachment to the linkage which leads to the free end of the Bourdon tube is also shown in figure 32, as well as the two bearings on the ends of the horizontal axis.

(6) *Bourdon tube.*—The Bourdon tube is the actuating element of the thermograph. A drawing of this part is shown in figure 33. It consists of a phosphor-bronze, closed, bent tube, one end of which is fixed to the frame while the other end is attached, by several linkages, to the pen arm. The tube is oblong in cross section. It is filled with alcohol, and is located outside the instrument case for ventilation and free exposure. It is usually furnished with a highly polished gold-plated surface to minimize the effects of radiation. Its curvature and, therefore, the indicated temperature can be changed by use of the temperature adjusting screw. The reading of the thermograph is always adjusted to the reading of the dry-bulb thermometer at the time of changing record sheets and at other times when the error of the thermograph becomes too large.

c. Installation.—The thermograph is installed in the instrument shelter. It must be so placed that there will be no interference be-

tween it and the other instruments, such as the maximum and minimum thermometers and the psychrometer. At the same time the several thermometer bulbs should be placed as near together as is convenient.

d. Reading.—The thermograph is always read to the nearest $\frac{1}{10}°$ Fahrenheit.

e. Care.—(1) *Clock unit.*—(*a*) The clock provided with the thermograph is designed for out-of-door use under changing and extreme weather conditions. It must not be taken out of the metal drum in

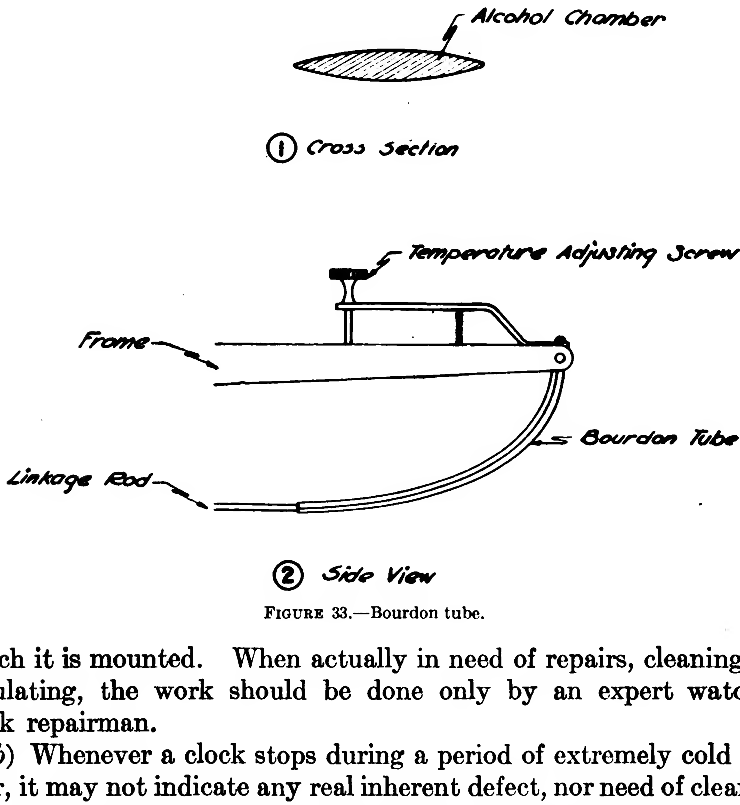


FIGURE 33.—Bourdon tube.

which it is mounted. When actually in need of repairs, cleaning and regulating, the work should be done only by an expert watch or clock repairman.

(*b*) Whenever a clock stops during a period of extremely cold weather, it may not indicate any real inherent defect, nor need of cleaning, but rather a stiffening of the lubricating oil that has been used in the delicate bearings. Under such conditions the instrument should be taken inside temporarily, to a temperature above freezing. Further effort should be made to start the clock by carefully giving it a rotating motion about its axis.

(*c*) Clock stoppage can sometimes be traced to undue friction between the clock gear and the daily or weekly pinion. In order to

correct the condition, lift the clock from the shaft. Slightly loosen the three peripheral screws which attach the interior clock mechanism to the clock base. It will be noted that the pinion shaft can now be shifted somewhat. Shift it to a position where no friction occurs at any point of an entire revolution, and hold this setting by tightening the three screws previously noted.

(*d*) The clock should be wound once a week, preferably at the time of changing the sheet. The clock should be wound completely.

(2) *Thermograph time error.*—In order to insure that the thermograph is operating on correct time, it is necessary that at each time of changing the record chart, the instrument be started with a zero time error. To do this, the observer should make the major adjustment for time as he lowers the cylinder and clock housing over the clock shaft, and before the clock gear is engaged. The next step is to turn the cylinder forcibly on its axis until the pen falls just a trifle to the right of the correct time as shown on the chart. Next touch

FIGURE 34.—Thermograph traces.

the top edge of the cylinder lightly with the finger tip and draw it off in a manner that will move the cylinder gently in the direction opposite to that in which it revolves. This latter operation will take up the lost motion, and the pen point should then indicate the correct time. If the pen does not rest on the correct time, the operation should be repeated until an exact adjustment is made.

(3) *Pen.*—(*a*) To insure good and accurate traces, the pressure of the pen on the record sheet must be very light. The constant-pressure pen arm of the newer thermographs provides for proper pressure without any care on the part of the observer. On the older thermographs there is an adjusting screw near the base of the pen arm, which permits adjustment of the pressure with which the pen bears against the chart. If the pen bears too heavily on the chart the record will appear as a series of quick changes in temperature rather than the more gradual change which is the usual case. Figure 34① shows a record obtained from a pen which was pressing too heavily on the chart. The excess friction on the paper was too great at the beginning of any change in temperature to permit the force, through the linkages from the Bourdon tube, to overcome it. As this force increased with a continued change in temperature of the same sign,

the friction of the pen on the paper was overcome and the pen suddenly adjusted itself to the changed shape of the actuating element. This process was repeated with the result that the record has the appearance of a series of steps. When the pen pressure is correct, a smooth curve, such as that shown in figure 34②, is the result.

(*b*) A good way to test for proper pen pressure is to tilt the top of the instrument forward to an angle of about 30°. If the pen pressure is correct, the pen will drop away from the chart when the instrument is in this position. If the pen fails to leave the chart, the pressure should be reduced.

(*c*) The pen barrel should never be filled more than half full of ink. Always use the special ink provided for use with this instrument. Due to the presence of alcohol and glycerin in this ink, it is somewhat hygroscopic. Hence, during conditions of high relative humidity such as foggy weather, or during prolonged periods of mist or light rain, this ink will absorb considerable moisture and its bulk will increase, often to the extent that the barrel becomes completely filled and overflows. The excess ink either hangs as a drop outside the barrel or runs down the pen arm. Observers should always look for this condition during the prevalence of such weather as described above. As soon as this condition develops, the pen barrel should be emptied completely by use of a small piece of blotting paper, and a new supply of ink introduced. Do not merely remove the excess ink from outside the barrel and that which may have run down the pen arm. That which is left in the barrel is considerably diluted and will make an illegible record. Unless this ink is replaced, a part of the record is liable to be lost.

(*d*) About once a month, the pen should be removed from the pen arm and all old, dried ink removed by washing the pen in warm water. Be careful to avoid bending the pen in any degree. After long usage, these pens will become too blunt to enable them to draw a fine enough line. When this is discovered, a new pen should be substituted. If, after installing of a new pen or replacing of a pen after cleaning, the ink does not readily start flowing between the capillary leaves, the flow can be started by drawing a small piece of hard bond paper between the pen leaves. The pen should then be inspected to see that no fibre remains attached.

(4) *Temperature error.*—At the time of changing the record sheet, the thermograph should be adjusted to zero temperature error. The temperature adjustment screw is used for this purpose. In setting, it is advisable to tap the instrument lightly in order to cause the various parts and linkages to settle into their normal positions.

When, for any reason, the thermograph has developed an excessive temperature error (more than 5°), it should be adjusted without waiting for the next change of the chart.

(5) *Bearings.*—After continued long usage, or following a period when the air has been unusually dusty, the bearings at the ends of the horizontal axis should be wiped clean with a soft cloth and a small drop of good watch oil applied.

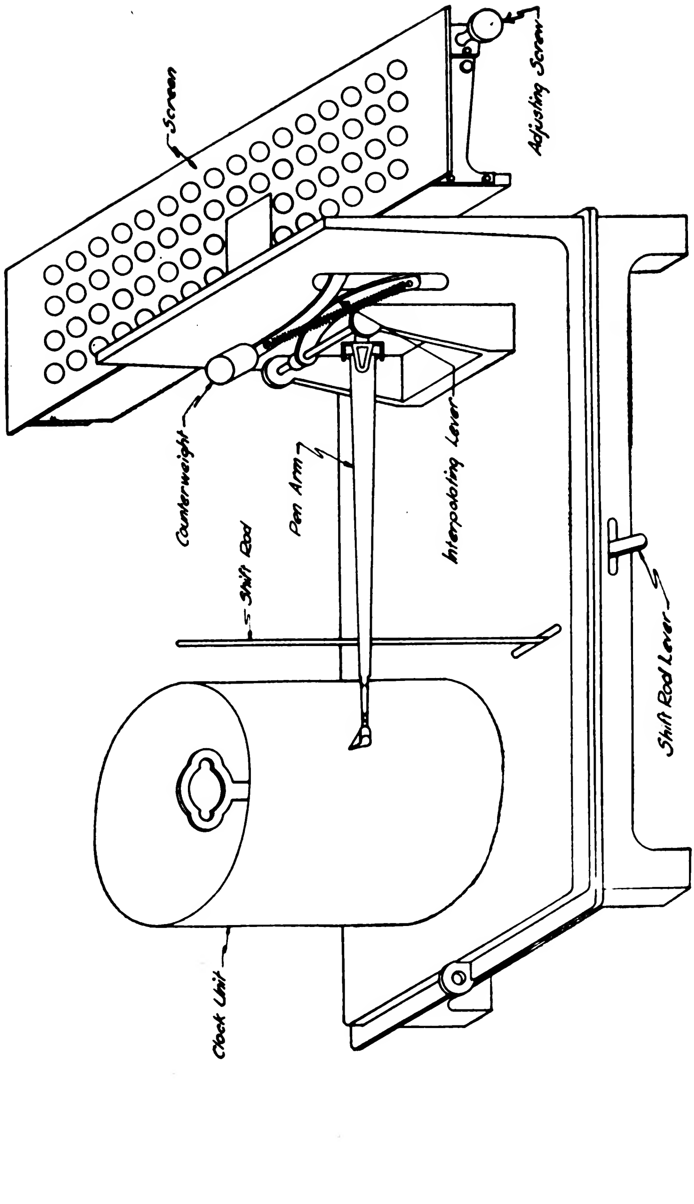
(6) *Lever-length adjusting screw.*—(*a*) It is frequently noted that the thermograph will record too low a temperature at the time of maximum temperature and too high a temperature at the time of minimum temperature. In this case the pen arm is not swinging over a large enough arc because it is too short. Often a minor adjustment of the pen on the pen arm will correct this. If the correction cannot be made in this manner, the fulcrum should be moved slightly to the right by operating the lever-length adjusting screw.

(*b*) If the thermograph records too high a temperature at the time of maximum temperature and too low a temperature at the time of minimum temperature, the pen arm is swinging over an arc that is too long. This, too, can be corrected either by adjusting the position of the pen farther back along the pen arm or by moving the fulcrum to the left.

(7) *Bourdon tube.*—About the only care required for the Bourdon tube is that it should be kept free from collecting dust. It should be wiped with a soft cloth about once each week.

8. Hygrograph.—*a. Purpose.*—The hygrograph is used to secure a continuous and automatic registration of relative humidity.

b. Description.—(1) *General.*—Figure 35 shows a sketch of a hygrograph, with its cover case removed. The principal parts and features of this instrument have been labeled. Detailed drawings of each part will follow. The actuating element of the hygrograph is a specially treated strand of human hairs. The long tubular strands with their great surface exposed seem constructed by nature to be suitable sensitive elements for the measurement of humidity values. As the moisture content of the air changes, the length of each hair changes. The strand is held fixed at both ends while the system of linkages of the hygrograph is attached to the middle of the strand. Change in the length of the strand of hairs is communicated through the system of linkages to a tracing point, and thus a continuous record of humidity changes and values is recorded on a moving surface. As humidity increases the hairs lengthen and the tracing point is moved upward. As humidity decreases the hairs become shorter


Screen
Adjusting Screw
Counterweight
Pen Arm
Interpolating Lever
Shift Rod
Shift Rod Lever
Clock Unit

① Side view.

② End view.

Figure 35.—Hygrograph.

and the arrangement of the linkage system causes the pen to move downward.

(2) *Clock unit.*—The clock unit of the hygrograph is similar to that of the thermograph as discussed in paragraph 7*b*(2). The only difference is that the cylinder for housing the clock movement is not as tall as that used in the thermograph, there being no necessity for changing the range of scale of the chart in the case of the hygrograph. All charts are of the same size and are designed for records of relative humidity from 0 to 100 percent. There is no compartment for auxilliary gears, but the clock is designed for the use of weekly or daily gears and pinions as desired.

(3) *Pen.*—The pen used on the hygrograph is exactly the same as that used on the thermograph, as described in paragraph 7*b*(3).

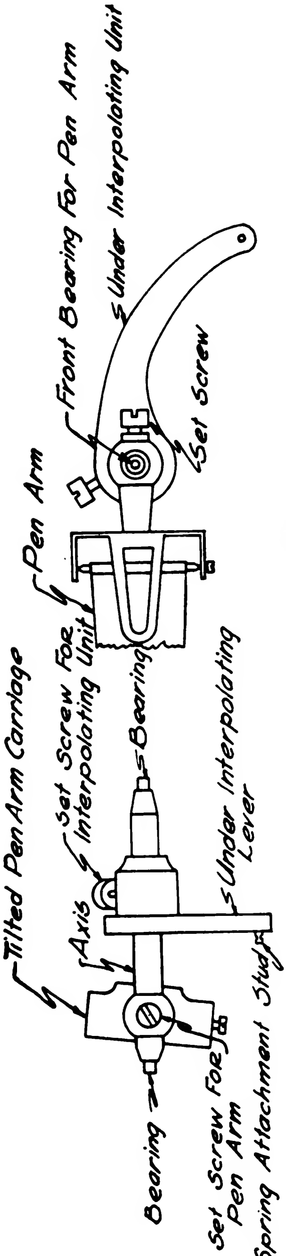
(4) *Pen arm.*—The pen arm used on the hygrograph is the constant-pressure type, and is exactly the same as that used on the thermograph. It is fully described in paragraph 7*b*(4).

(5) *Front horizontal axis.*—(*a*) The horizontal axis provides the means of attachment between the pen arm and the first element in the system of linkages which connects to the strand of hairs. Figure 36① shows the two bearings at the ends of this axis. They fit into the carriage which extends upward from the right end of the base surface of the hygrograph. The attachment for the pen arm is the same as in the thermograph.

(*b*) To the right of the pen arm attachment we find the first element in the system of linkages. This element is a mechanical arrangement of two curved surfaces known as an interpolating lever. Only the under unit of this lever is shown in figure 36. It is held to the horizontal axis by a setscrew. The setscrew permits of this lower unit being shifted on the axis and thereby providing some adjustment of the sweep of the pen arm. However, the position of this lower unit has been carefully arranged by the manufacturer and should ordinarily not be changed. A more direct means for adjustment of the movement of the pen arm will be discussed later. Figure 36② shows a front view of the horizontal axis and its attachments.

(6) *Interpolating lever.*—(*a*) The interpolating lever is an important element in the system of linkages. It is a mechanical arrangemen which introduces the feature of a changing length of lever arm, which is necessary to provide compensation for the changing characteristics of the actuating strand of hairs.

(*b*) Figure 37 shows a side view of the interpolating lever and its attachments to the front and rear horizontal axes. The middle por-



① Side view. ② Front view.

FIGURE 36.—Front horizontal axis.

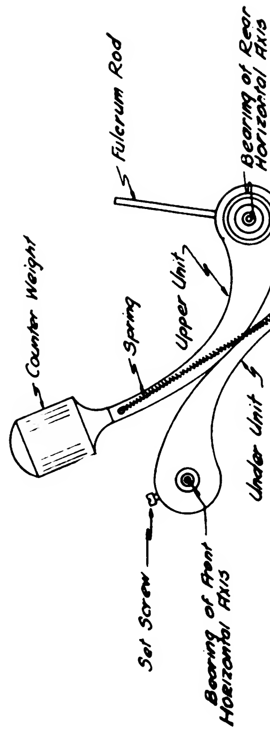


FIGURE 37.—Interpolating lever.

tion of the strand of hairs is attached to the fulcrum rod, as will be shown in detail in a following subdivision of this paragraph. Any movement of the hairs is communicated to the rear axis through this fulcrum rod. As the hairs shorten due to decreasing humidity, the fulcrum rod will be pulled to the right. Thus the rear axis is rotated clockwise. The upper unit of the interpolating lever is fixed to the rear axis and will, therefore, be rotated about this axis also in a clockwise manner. As the upper unit partakes of such motion, the lower unit, with its attached front axis, is rotated counterclockwise. Since the pen arm is fastened to this front axis, the pen will, in this case, be carried downward over the chart. Thus, with a shortening of the hairs, a lower humidity value is recorded.

(*c*) The two units of the interpolating lever are held in contact along their convex surfaces by the spring shown in figure 37.

(7) *Rear horizontal axis.*—The rear horizontal axis provides com-

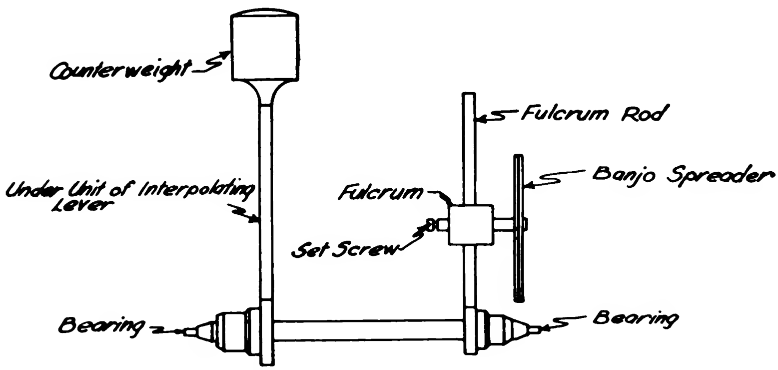
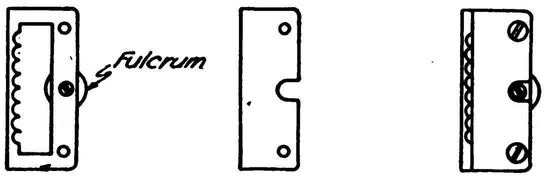


FIGURE 38.—Rear horizontal axis with attachments.

munication of movement from the strand of hairs to the interpolating lever. Figure 38 shows a view of the rear horizontal axis, with attachments. The bearings are shown at the two ends. The upper unit of the interpolating lever is shown with its attachment to this axis. Near the right end of this axis is shown the attachment of the fulcrum rod and fulcrum. The fulcrum is held in place by the setscrew. By loosening this screw, the fulcrum can be shifted up or down on the fulcrum rod. If it is shifted upward, the effective lever length is increased so that the sweep of the pen arm, for a given change in length of the strand of hairs, is increased. If the fulcrum is moved downward, the effective lever length is decreased. A device for spreading the strand of hairs, called the banjo-spreader, is attached to the right side of the adjustable fulcrum.

(8) *Banjo-spreader.*—As a means of exposing the hairs of the hygrograph to best advantage, in order to increase the sensitivity of the instrument, the strand of hairs is spread apart into several finer strands. The device for maintaining this separation is called the banjo-spreader. Figure 39 shows the parts of this spreading device. The base plate is shown to have eight semicircular notches for holding



① Base plate. ② Top plate. ③ Assembled.

FIGURE 39.—Banjo-spreader.

the eight smaller strands of hair. Figure 39① shows a side view of this plate looking from the rear side of the hygrograph. The attachment of this plate to the fulcrum is also illustrated. Figure 39② shows the top plate and ③ shows the two parts assembled.

(9) *Strand of hairs.*—The actuating element of the hygrograph is a strand of human hairs which has been specially cleaned and processed. The strand consists of approximately 50 hairs. This is divided into eight smaller strands for the purpose of exposing each individual length of hair to the best advantage and thereby increasing the sensitivity of the instrument. The mounting of the hairs is shown in

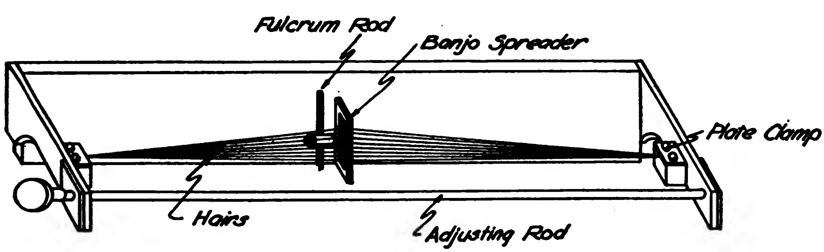


FIGURE 40.—Strand of hairs.

figure 40. Two small plate clamps, mounted at the ends of the outside brass frame, serve to hold the ends of the strand firmly in place. The spreading arrangement and its attachment to the fulcrum rod can be seen also in this figure.

(10) *Adjusting rod.*—The adjusting rod is used to set the instrument to zero correction at the time of changing record charts or at other times when the instrument may be indicating a humidity value

too much in error. This rod is shown in figure 40. It has right-handed threads cut near the left end and left-handed threads cut on the right end. When the knurled-headed nut is turned clockwise, the parts of the frame to which the ends of the strand of hairs are clamped are spread farther apart, thus shortening the strand. By this means the pen is lowered on the chart. Turning the knurled head counter-clockwise results in a lengthening of the hairs, and the pen is moved upward.

c. *Installation.*—The hygrograph is installed in the instrument shelter. At the time of installation a careful determination of the relative humidity should be made by use of a psychrometer, and the pen of the hygrograph should be adjusted to a zero correction.

d. *Reading.*—The hygrograph is always read to the nearest whole percent.

e. *Care.*—(1) *Clock unit.*—The clock used in the hygrograph is similar to that used in the thermograph, and remarks concerning its care are contained in paragraph 7*e*(1).

(2) *Hygrograph time error.*—The hygrograph is subject to the same time error as found in the thermograph. The method of insuring that the hygrograph is operating on correct time is the same as that discussed in paragraph 7*e*(2).

(3) *Pen.*—The discussion concerning the care of the hygrograph pen is fully covered in paragraph 7*e*(3).

(4) *Humidity error.*—At the time of changing the record sheet, the hygrograph should be adjusted so that the new record starts off with a zero correction. To do this, an accurate determination of the relative humidity is made by use of a psychrometer and then the pen is adjusted to the proper humidity reading on the chart by use of the adjusting screw. In making this adjustment it is advisable to tap the instrument lightly in order to cause the various parts to settle into their normal positions. The pen must rest in proper position after the tapping. When, for any reason, the hygrograph has developed an excessive error (more than 5 percent), it should be adjusted without waiting for the next change of the chart.

(5) *Bearings.*—The bearings on the front and rear horizontal axes should be kept free of dust and should have a slight amount of good clock oil applied. The rear axis, due to its more open exposure, is subject to a greater and more rapid accumulation of dust and dirt. Also, some rust is frequently found to have formed here. To care properly for these bearings, a partial disassembling of the instrument is necessary, but this should be done about once during each 3-months' period.

(6) *Interpolating lever.*—The interpolating lever will require very little attention or care. Although the sweep of the pen arm can be changed by changing the position of the lower unit of this lever on the front horizontal axis, this position has been carefully adjusted by the manufacturer and should normally not be disturbed. The units of this lever must be separated and the counterweight of the upper unit removed during times when the bearings of the horizontal axes are cleaned.

(7) *Strand of hairs.*—The strand of hairs should occasionally be brushed free of all dust. A small camel's-hair brush is best suited for this purpose. In some localities, the hair becomes clogged with an excessive amount of dirt and some oil droplets. When such a condition exists, the strand should be removed and carefully washed in clean warm water. Do not use gasoline, carbon tetrachloride, or any substance other than clean water for this cleaning. After cleaning, allow the hairs to dry thoroughly before reinstalling them. Be careful at all times to avoid touching the hairs with the fingers. Oil deposited from the fingers on the hairs makes them less sensitive to humidity changes. After long usage, some of the hairs will deteriorate and break. Whenever as many as five or six hairs have been broken, the strand should be replaced by a new one.

(8) *Adjusting rod.*—The adjusting rod should be kept free from dirt and dust. A small drop of oil should occasionally be placed on the threads.

9. Fortin-type mercury barometer.—*a. Purpose.*—The purpose of the mercury barometer is to measure accurately the pressure of the air.

b. Description.—(1) *General.*—In order that the height of the mercury column may represent accurately the true pressure of the air, and in order to detect the comparatively small changes of pressure from day to day, many refinements are necessary in construction of the instrument and great precision of measurement is required. An excellent form of the mercury barometer, satisfying the requirements just stated, was devised by Fortin, and is now widely used the world over. The particular pattern used by the Amry Air Forces Weather Service is shown in figure 41.

(2) *Tube and casing.*—The barometer (fig. 41) consists of a glass tube about ¼-inch inside diameter closed at the top and inclosed in a thin metal casing, through which large openings are cut on opposite sides, exposing to view a section of the glass tube and mercury column. A graduated scale is formed at one side of this opening. In addition,

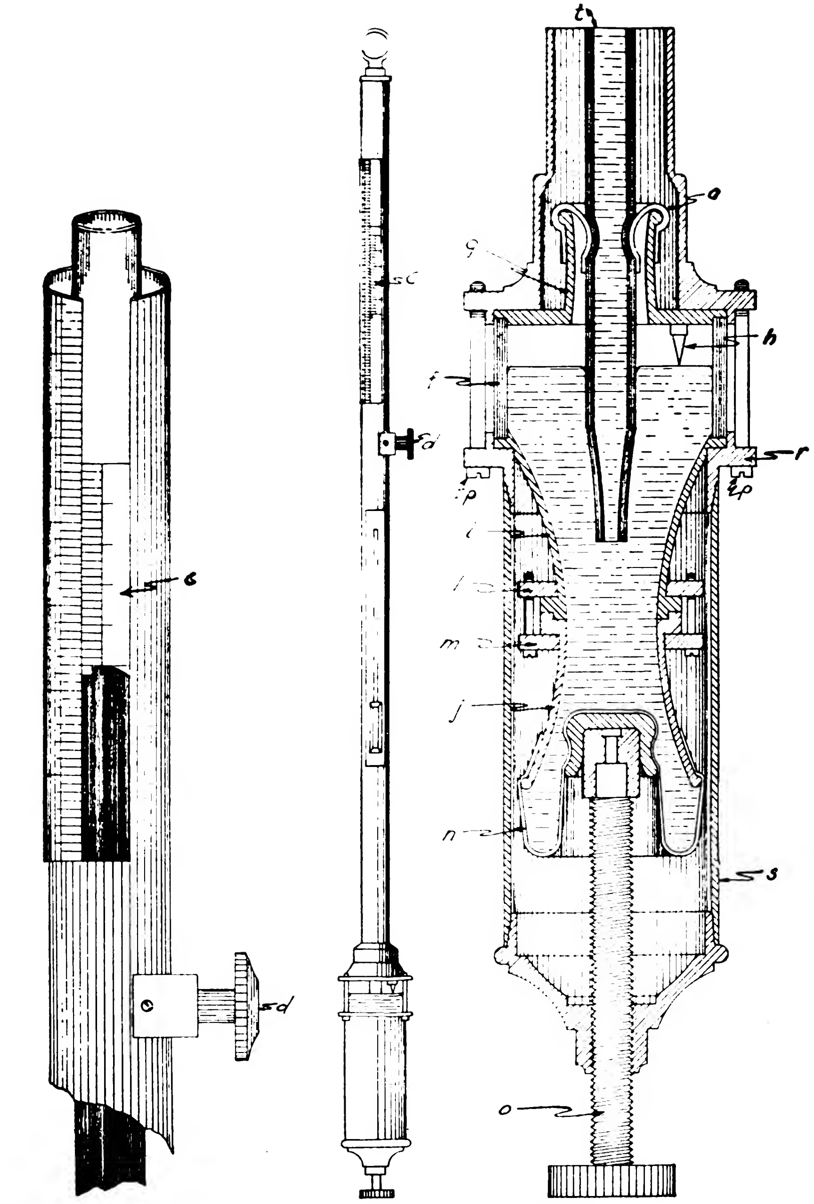


FIGURE 41.—Mercury barometer with Fortin cistern.

a short sleeve, also graduated, encircles the barometer tube and slides smoothly within the metal casing, motion being given to it by means of the milled head *d*. The milled head operates a small rack and pinion inside the casing.

(3) *Attached thermometer.*—In order to measure accurately the temperature of the mercury and the metal scale, the latter being a part of the casing, a thermometer is placed about half way between the cistern and the top of the barometer. This is known as the attached thermometer, and it is so placed that the bulb is exposed between the brass casing and the mercury column.

(4) *Cistern.*—The special feature of the barometer is a cistern so constructed that the level of the mercury within may be changed greatly and adjusted to a fixed index point. The topmost portion of the cistern consists of a small boxwood piece *g*. The glass tube *t* passes through the central part of this piece, to which it is secured by a piece of soft kid leather, folded in a special manner and securely wrapped to both the glass tube and the boxwood cap *g*. This piece of leather is shown at *a*. The flexible joint thus formed will not allow the mercury to escape, but permits passage of air to and from the cistern. The remaining portions of the cistern are the short glass cylinder *f*, the two curved boxwood pieces *i* and *j*, the split-ring clamps *l* and *m*, the kid-leather bag *n*, and the adjusting screw *o*. Through operation of the adjusting screw *o*, the leather bag may be folded up into or withdrawn from the lower part of the cylinder, thus causing any desired change in the level of the mercury surface in the cistern.

(5) *Ivory point.*—Projecting downward from the right under surface of the boxwood piece *g* is a small conical piece of ivory, marked *h*. This cone-shaped piece is inverted. The apex forms a fixed and definite point, to which the level of the mercury in the cistern can be adjusted in taking readings of the barometer. This ivory point is, therefore, the zero end of the scale, from which all the measurements of the height of the column are made.

(6) *Barometer scale.*—The scale of the barometer is shown on the left of the opening in the brass casing. It is most conveniently made of a separate strip of metal, although sometimes it is engraved directly on the metal tube itself. The length varies from about 4 inches, for use at stations of only moderate elevation above sea level, to from 10 to 15 inches or more, for barometers intended to be used at high elevations. The graduations on the scale also vary, being only 10 spaces to the inch in many instances and 20 in others. The larger number of graduations for a given length of scale provides

for greater accuracy in readings. Most of the barometers in use in the Army Air Force Weather Service have 20 graduations to the inch. The scale of the barometer, when engraved on a separate strip, is attached to the metal tube by small screws in such a manner that it may be adjusted slightly, either up or down, so that the 30-inch mark of the graduations, for example, can be placed at exactly the right distance from the ivory point. This adjustment is always made by the manufacturer and should not be changed.

(7) *Vernier.*—(*a*) The vernier is a device by which one is able to ascertain accurately much smaller fractional subdivisions of a graduated scale than could otherwise be observed by the eye. For example, with a scale having only 20 subdivisions to the inch, the

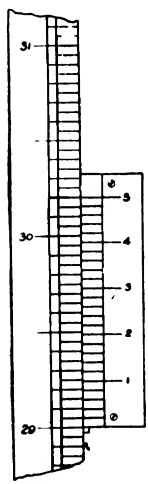


FIGURE 42.—Barometer vernier.

smallest subdivision represents 0.05 inch. By careful estimation the reading of such a scale could be made with sufficient accuracy to 0.025 inch without the aid of a vernier. However, with a vernier, the reading could be made to 0.001 inch. The name of the device is derived from its inventor, Pierre Vernier. This part of the barometer is shown at *c*. A larger scale drawing of the vernier is shown in figure 42.

(*b*) A vernier consists, essentially, of a relatively short graduated scale, the spaces upon which are just a certain amount smaller or larger than those of the main scale. When two such scales are placed together, some marking of the vernier will be coincident, or very nearly so, with a line on the scale, and from this circumstance the position of the zero line of the vernier in reference to the scale can be determined accurately.

(c) In the vernier shown in figure 42, 24 graduations on the scale are equivalent to 25 graduations on the vernier. Hence each interval on the vernier is one twenty-fifth of a scale interval smaller than a scale interval. Thus, if the vernier is arranged, with respect to the scale, so that the zero of the vernier is coincident with a given scale marking, the first vernier marking above zero will be one twenty-fifth of a scale interval below its nearest scale marking. If the vernier is now raised so that the first vernier marking above zero is brought into coincidence with the nearest scale marking, the vernier will have been raised through that distance one twenty-fifth of a scale interval. Inasmuch as there are 20 scale intervals to the inch, in this example the vernier has been raised $\frac{1}{25}$ of $\frac{1}{20}$ inch or 0.002 inch. Since the reading is to be taken from that vernier marking in, or nearest to, coincidence with a scale marking, and since in our example that vernier marking is the first above the vernier zero, each interval on the vernier must represent 0.002 inch.

c. *Errors of mercury barometers.*—(1) *General.*—No matter how carefully a barometer may be made, certain errors due to various causes can hardly be eliminated. In the first place, if any residual air or vapor or any kind of gaseous matter remains in the top of the barometer tube, the column of mercury will not rise as high as it should. Moreover, we know from physical laws that the capillary forces acting between the free surface of mercury and the glass walls at the top of the column also operate to prevent the mercury from rising as high as it should. Still other errors arise from faults in the graduation of the scale, and from failure to place it and the vernier at exactly the positions they should occupy. It is not practicable or necessary, as a rule, to determine these errors separately. When an instrument is completed, its readings are carefully compared with those of a standard barometer. The differences found in this way represent the outstanding effect of the several sources of error mentioned above, and are commonly called "the correction for instrumental error and capillarity." There is still another source of considerable variation in readings of mercury barometers, namely, the influence of temperature. A change in temperature affects the length of both the metal scale and the mercury column.

(2) *Correction for capillarity.*—In all barometers having comparatively small tubes, that is, of less diameter than from 0.7 to 1 inch, the top of the mercury column, or the meniscus, as the rounded surface is generally called, will nearly always be quite convex on account of the capillary action between the mercury and the glass.

In consequence of this, the mercury column is actually depressed a slight amount and never indicates the true barometric height. This source of error is one of the most troublesome to which barometers are subject, as the capillarity is never quite constant and there is no practicable method by which its changing value can be determined accurately in the daily use of an instrument. The error due to capillarity is nearly always eliminated as far as possible from the scale reading by adjusting the scale so that allowance will be made for the average capillary depression. If an ordinary barometer be carefully examined, it will be found that the 30-inch mark on the scale is appreciably less than 30 inches from the ivory point. In general, the difference represents the amount the mercury column is depressed by capillarity.

(3) *Correction for imperfect vacuum.*—It is generally assumed that the space in a barometer tube above the mercury column is a perfect vacuum, and that there is no downward pressure upon the top of the column of mercury. This, however, is not strictly the case in any instance, and often an appreciable quantity of air or water vapor is present. Any vapor that the mercury may give off is always present. This latter, however, is very small and is never considered except in the most refined investigations. If, therefore, any such pressures exist upon the top of the column, it will be depressed, and a correction, which may properly be called correction for imperfect vacuum or reduction to perfect vacuum, should be applied. Such a correction will vary with both the temperature and the volume of the space. If the trace of air present is slight, as is nearly always the case in any good barometer, the correction for vacuum will be nearly constant, provided the volume is not changed much by great changes of pressure, since the changes corresponding to ordinary changes in temperature are comparatively small. Therefore, in ordinary weather-station barometers this correction, like the one for capillarity, is included in the correction for instrumental error. When, however, a barometer is used at both high and low pressures, the volume of the vacuum space may change manyfold, and in such a case any error due to imperfect vacuum is far from being constant.

(4) *Correction for instrumental or scale error.*—(*a*) Errors arising from several independent sources are embraced under this designation. for example: The graduated scale may not be adjusted so perfectly that its divisions are at exactly the right distance from the ivory point; the sighting edge of the vernier may not be true or in proper correspondence with its zero graduation line; unavoidable errors and irregu-

larities in the graduations of the barometer scale itself also introduce different errors from point to point along the scale. Nevertheless, sufficient precision in scale graduation is easily attainable even in a scale that is only fairly good, and such errors are generally so small as to be unimportant in ordinary barometric observations, and are seldom considered. The combined effect of such sources of error gives rise to what is generally called the correction for instrumental or scale error.

(*b*) The manufacturer, in adjusting a good barometer, endeavors to eliminate as completely as possible, or at least to reduce to a very small quantity, the several corrections mentioned, viz, correction for capillarity, for imperfect vacuum, and for instrumental error. This he can do by sliding the scale up or down a small fraction of an inch until he finds, by repeated trials and comparative readings with a standard instrument, that the new barometer, when corrected for temperature, gives the same or nearly the same readings as the standard. Any slight outstanding difference that may finally remain then becomes the "correction for instrumental error, including capillarity," or briefly "correction for scale errors and capillarity."

(*c*) By comparing a barometer in a partial vacuum so as to ascertain the "correction for scale errors and capillarity" at several pressures, such, for example, as at each inch between 20 and 30 inches of pressure, it has been learned in a few cases that very great differences in the correction may be found at different points of the scale. These differences amounted in one case to eighty-three thousandths of an inch between 25 and 30 inches, and could not be explained by any error of the scale or by any influence other than that of the irregular capillary action at different points of the tube. These investigations demonstrated the necessity for ascertaining correction for scale errors and capillarity of each instrument for the particular pressure range through which the instrument is to be used.

(5) *Correction for temperature.*—(*a*) The temperature of a barometer affects the accuracy of its readings in two ways. First, the metal scale expands and contracts with changing temperatures, and is, therefore, continually changing its length. Second, the mercury itself expands and contracts much more than the scale. The 30 cubic inches of warm mercury in a barometer tube at, say, a temperature of 80° F., will be more than 1 ounce lighter than the same volume of mercury at freezing temperature. The true pressure of the air, therefore, is not shown by the observed height of the mercury column until we take into account both the temperature of the scale and the

density of the mercury. For this reason barometric readings require to be reduced to a reading which would have been obtained had the mercury and scale been at certain standard temperatures.

(*b*) The standard temperature adopted for the mercury is always that of melting ice, that is, 0° C., or 32° F. When the readings of the scale are taken in inches, the standard temperature for the scale reduction is 62° F. If, however, the metric unit of length is used, the standard temperature is 0° C. In the latter case the same temperature serves for both the scale and the mercury. There is thus a disparity between the temperatures at which English and metric scales are of standard length; moreover, tables of barometric corrections for temperature usually give the reduction for both the scale and the mercury in one correction, whence it follows from these two circumstances that the corrections in English and in metric tables are not mutually convertible. An error is therefore introduced if the uncorrected reading of a mercury barometer, expressed in metric units, is converted into English units, or vice versa, and a temperature correction afterwards applied to the result. Conversion of barometer readings from English to metric or from metric to English units can be made correctly only *after each reading has been fully corrected for temperature*.

(*c*) Tables of correction are computed by simple formulas taking into account the known coefficients of expansion of the mercury and of the metal or material of which the scale is made. The scale in this type of barometer includes all the metal parts between the ivory point and the top of the column of mercury. It is generally assumed that the temperatures of the scale and mercury are the same, and that the temperature is given by the indications of the attached thermometer. For barometers with brass scales the following formula is used for computing corrections:

$$C=-h\frac{t-28.630}{1.1123t+10.978}$$

in which h is the observed reading of the barometer *in inches*, and t is the temperature of the scale and mercury in degrees Fahrenheit. The numerical factors in this equation are obtained by using the following values for the expansion of mercury and brass, viz:

Cubical expansion of mercury—0.0001010 per degree Fahrenheit.

Linear expansion of brass—0.0000102 per degree Fahrenheit.

An extract of the tables for the temperature correction for mercury barometers, with brass scales graduated in English units, is shown in table I.

TABLE I.—*Correction of mercury barometer for temperature—English units*

	26.5	27.0	27.5	28.0	28.5	29.0	29.5	30.0	30.5	31.0
					ADD (Inches)					
21	0.018	0.019	0.019	0.019	0.020	0.020	0.020	0.021	0.022	0.022
22	.016	.016	.016	.017	.017	.017	.018	.018	.018	.019
23	.014	.014	.014	.014	.014	.015	.015	.015	.016	.016
24	.011	.011	.012	.012	.012	.012	.012	.013	.013	.013
25	.009	.009	.009	.009	.010	.010	.010	.010	.010	.010
26	.006	.006	.006	.007	.007	.007	.007	.007	.007	.007
27	.004	.004	.004	.004	.004	.004	.004	.004	.004	.005
28	.002	.002	.002	.002	.002	.002	.002	.002	.002	.002
					SUBTRACT (Inches)					
29	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
30	.003	.003	.003	.003	.004	.004	.004	.004	.004	.004
31	.006	.006	.006	.006	.006	.006	.006	.006	.007	.007
32	.008	.008	.009	.009	.009	.009	.009	.009	.009	.009
33	.011	.011	.011	.011	.011	.012	.012	.012	.012	.012
34	.013	.013	.013	.014	.014	.014	.014	.015	.015	.015
35	.015	.016	.016	.016	.016	.017	.017	.017	.018	.018

Note that, in agreement with the formula, if the attached thermometer reading is 28.630° F., the correction for temperature is zero.

(6) *Correction for density of mercury.*—If the density of the mercury is not the same in two barometers that are exactly alike in every other respect, the heights of the mercury columns will not be the same for the same pressure. In such a case a reduction to mercury of a standard density will be required. The presence of 1 percent of lead with mercury causes a change in density that would require a correction of about 0.051 of an inch. On the other hand, mercury containing even so little as one one-hundredth of 1 percent of lead is rendered so exceedingly foul that it could not be used for barometric purposes. It is therefore easily seen that a correction for standard density is a refinement which need not ordinarily be considered.

(7) *Evaluation of corrections.*—(*a*) It is easily understood, after what has been said above about errors of graduation, errors due to capillarity, to imperfect vacuum, to instrumental imperfection, etc., that even the best of ordinary barometers is liable to be quite incorrect until corrections for these errors have been determined. Moreover, from the nature of things, we cannot determine these corrections except by comparison with a standard barometer, and the question might

properly be asked about how it is known that the standard barometer is right. To understand the answer to this question, it must first be stated that the standard barometer, used for comparison, must be a normal barometer.

(*b*) A standard barometer need not necessarily be anything more than an instrument which has been pronounced to be correct by some special authority. Such an instrument, although formally pronounced to be a standard, might, nevertheless, possess little more than the average accuracy and its indications might still be more or less erroneous. Since the several errors of barometers cannot be determined, in the majority of cases, except by comparison with an instrument whose errors are all known, a standard based only on the dictum of some authority cannot necessarily be regarded as giving true indications. A normal barometer, however, is, by definition, one the construction of which is such that the instrument, fundamentally and independent of all other similar instruments, gives a true measure of the pressure of the air.

(*c*) It must not be understood that a normal barometer is absolutely without error. The construction, however, is such that those errors which cannot be eliminated wholly can yet be ascertained from the indications of the instrument itself. The error for capillarity, for example, is wholly eliminated by employing a tube of very large diameter. The error for imperfect vacuum in the normal barometer is made known by having the barometer so constructed that readings may be made when the vacuum chamber is large, and again when it is many times smaller. As the volume of the vacuum chamber is reduced, the pressure of the vapor and air therein is proportionately increased, and from the several readings made under conditions of different volumes of the vacuum space, the correction for imperfect vacuum can be computed. So, also, other errors are either eliminated or are evaluated through the special construction of the normal barometer and by special investigations, and the reading of the barometer after all known corrections are made is regarded as fundamentally correct. Normal barometers are generally of elaborate construction and will not be described in this manual.

d. Installation.—(1) *Barometer box.*—The mercury barometer is installed inside the weather station and is normally mounted in a special barometer box, such as shown in figure 43. This box must be attached securely to a wall or to some other rigid support, and in a location that affords good light and does not subject the barometer to sudden changes of temperature. In mounting this box every effort should be made to insure that it is placed in a truly vertical position.

(2) *Proper light.*—The position selected for mounting the barometer should be such that adequate light is reflected from the two milk glass sections onto the cistern and the top of the mercury column. Artificial

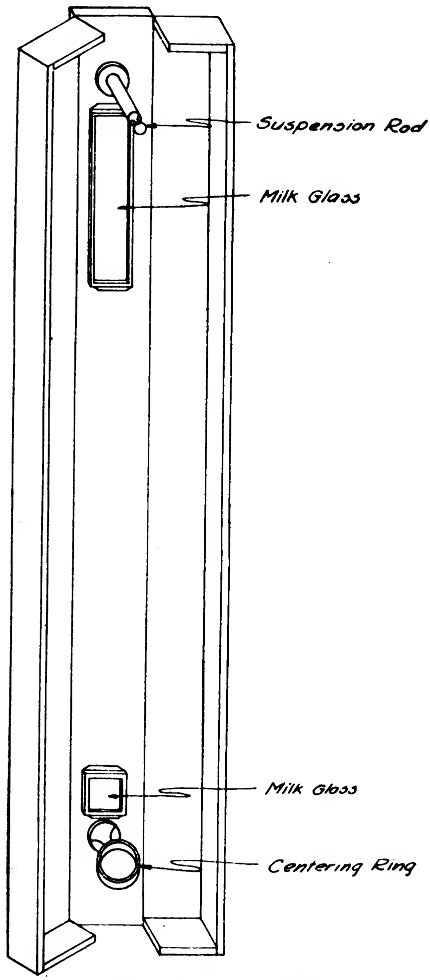


FIGURE 43.—Barometer box.

lights should be installed along the outside of the box for use during nighttime observations.

(3) *Height.*—The top of the mercury column should be about the height of the observer's eye.

(4) *Temperature control.*—The barometer should not be exposed either to the direct rays of the sun or to air currents that are always

found in the vicinity of cracks and crevices near windows and doors.

(5) *Verticality.*—(*a*) For accurate results it is necessary that barometers should be exactly vertical when the adjustments for reading are made. As the barometer hangs from the suspension rod, the instrument itself acts as a plumb line and takes a vertical position. It is desirable, however, for convenience in setting the barometer, as well as to insure permanent verticality of the instrument, to steady it in supports which are first adjusted, once for all, so that the barometer is accurately vertical.

(*b*) The centering ring and centering screws shown in figure 44 are used to insure verticality. If the barometer box has been properly mounted so that it is vertical, the barometer will hang from the

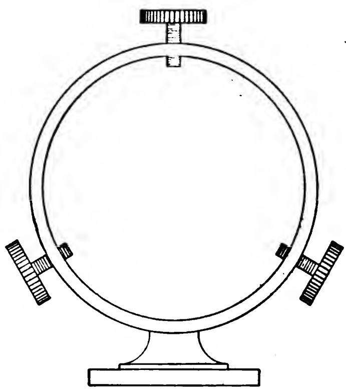


FIGURE 44.—Barometer centering ring.

suspension rod in such a manner that the cistern rests free from any contact with the centering ring. A careful adjustment of each of the centering screws will fix the barometer for permanent verticality.

e. Reading.—(1) *Attached thermometer.*—The presence of the observer's body near the barometer tends to affect its temperature. The scale and outer parts are affected first, then the thermometer, and much more slowly the mercury column. Generally, however, this effect is slight, since only a very few minutes are required in making the reading. It is best to read the attached thermometer as the first operation in reading a barometer. This thermometer is read to the nearest one-half degree Fahrenheit.

(2) *To "set" cistern.*—First, tap the casing of the cistern lightly with the finger tips in order to insure that the mercury surface is free from any tendency to cling to the glass walls. Next, adjust the top surface of the mercury so that it is just in contact with the ivory

point. To make this contact adjustment, there are three slightly different methods that may be followed.

(*a*) *First method.*—Lower the mercury in the cistern until a definite separation of, say, ⅛ to ¼ inch exists between the ivory point and the mercury surface. This is accomplished by operating the adjusting screw (fig. 41) while sighting along the top surface of the mercury to the lower section of milk glass background. Now, while sighting in the same manner, raise the mercury and watch for the slightest thread of light that can be detected between the ivory point and the mercury. Turn the adjusting screw very carefully until this thread of light just disappears. The light should be strongly reflected from the milk glass, with the cistern somewhat in shadow. This method is believed to be the best of the three. It is applicable equally to new barometers with bright mercury surfaces and to older ones, the mercury of which is more or less oxidized.

(*b*) *Second method.*—Lower the mercury in the cistern until a space of ⅛ to ¼ inch separates the mercury surface from the ivory point. Now raise the mercury until a small dimplelike depression is made in the mercury as the ivory point is pressed into the mercury a little. Now lower the mercury carefully and slowly until the dimple just disappears. The surface of the mercury may now be supposed to be in contact with the ivory point. This method is not so reliable and accurate and, in general, can be followed only with clean mercury. Flakes of oxidized mercury on the surface in older barometers will make it impossible to use this method because the dimplelike depression will not readily be formed. Furthermore, as the ivory point is pressed into the mercury and then withdrawn, some mercury often clings to the ivory point, especially when the ivory is newly cut. It is not good practice to lower the mercury any slight amount, as a last operation, after it is once raised. The effect of this generally is to change simply the convexity of the meniscus at the top of the column, and this gives rise to a new and unknown correction for capillarity. The most uniform and accurate results are obtained by gradually raising the mercury until precise contact is secured. If it is believed that the mercury has been raised too much, lower it until entirely free from the point and start the adjustment again.

(*c*) *Third method.*—Another method that is sometimes used is first to lower the mercury to secure proper separation and then, while slowly raising it toward the ivory point, to watch closely until the reflected image of the ivory point coincides with the point itself. This method would require clean, bright mercury and is, therefore, not a general method.

(3) *Adjustment of vernier.*—The level of the mercury having been adjusted to the ivory point, the vernier must next be brought to the top of the column. First, in order to assure that the proper meniscus is formed, the metal casing near the top of the mercury column should be tapped lightly with the finger tips. Next, raise the vernier above the top of the mercury column, using the adjusting screw *d*, figure 41, and then lower it until the lower edge is brought just to the level of the extreme summit of the meniscus. Care must be exercised to insure that both the front and back edges of the vernier are in the line of sight. When the vernier is properly adjusted, two somewhat triangular areas can be seen to the left and right of the meniscus summit against the background of the upper section of milk glass. Figure

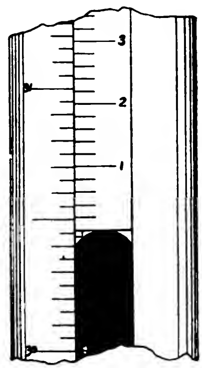


FIGURE 45.—Vernier adjusted to the mercury column.

45 shows a sketch illustrating the proper adjustment of the vernier to the top of the mercury column.

(4) *Reading vernier.*—(*a*) In order to understand the proper use of the vernier, let us examine figure 45. Notice that the scale is divided by graduations for each one-tenth of an inch. The problem of reading the scale accurately is to find the exact point along this scale on which the zero marking of the vernier rests. If the zero of the vernier has been adjusted to the top summit of the meniscus, the scale reading will show the length of the mercury column above the ivory point, due allowance having been made for slight adjustments of the position of the scale in efforts to reduce instrumental errors. The uncorrected reading, as made from the scale, is called the "observed reading." In this simple case it can readily be seen that the zero of the vernier rests between the 30.1-inch and the 30.2-inch markings on the scale. Thus we know that the observed reading is something less than 30.20 inches and something more than 30.10 inches. It appears to be about

halfway between these values. But instead of making an approximation from use of the scale graduations alone, let us use the vernier to find the reading more accurately.

(b) In this illustration, the vernier has ten divisions, each of which is nine-tenths as great as a division of the scale. If we look upward along the vernier graduations we note that graduation number 5 of the vernier is in exact coincidence with a scale graduation. We must determine exactly where the zero of the vernier rests. Since number 5 is in exact coincidence, and the distance between number 5 and number 4 is nine-tenths of the distance between scale graduations, then number 4 of the vernier is nine-tenths of a scale graduation below

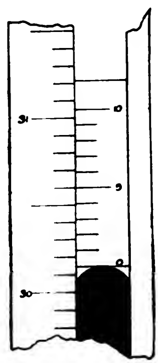


FIGURE 46.—Observed reading, 30.15 inches.

the scale graduation next above, viz, the scale graduation coinciding with number 5 of the vernier. Number 4 of the vernier is likewise one-tenth of a scale graduation above the scale graduation next below it. Number 3 of the vernier will be eight-tenths of a scale graduation below that line on the scale just above number 3, and it is two-tenths of a scale graduation above the scale marking just below it. And so on, number 2 of the vernier is three-tenths of a scale graduation above the scale marking below, number 1 is four-tenths above, and zero of the vernier is five-tenths of a scale graduation above the 30.10-inch mark. Thus in this case the true observed reading is 30.15 inches.

(c) Let us examine a setting just a little different, for the purpose of illustrating another point. In figure 47 we note that the zero graduation of the vernier rests between the 30.2-inch and the 30.3-inch markings of the scale. If we looked at this sketch carefully, we might estimate the reading to be 30.27 inches, or perhaps 30.28 inches. But the vernier will permit us to make the reading more accurately. In this case we note that no line of the vernier is in exact coincidence

with a line of the scale. Those vernier lines coming nearest to coincidence are numbers 7 and 8. Number 7 is a short distance above a scale marking and number 8 is a short distance below a scale marking. We might also notice that number 8 is closer to coincidence than is number 7.

(*d*) Let us first start with number 8 of the vernier. It is not quite high enough to be in coincidence. Thus number 7 is a little more than nine-tenths of a scale graduation below the next scale graduation above. It may also be said that number 7 is a little less than one-tenth of a scale graduation above the scale marking next below it. Number 6 is a little less than two-tenths, number 5 is a little less than three-tenths, and so on until zero of the vernier is found to be a little less

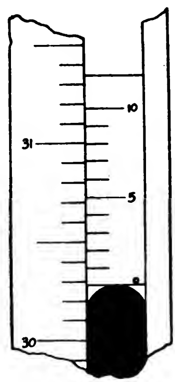


FIGURE 47.—Observed reading, 30.277 inches.

than eight-tenths above the next scale graduation below. Thus, by these steps in the reading operation, we have determined that the reading is a *little less than* 30.28 inches. If we start with number 7 of the vernier, we note that it is a little too high to be in coincidence with a scale graduation. Thus number 6 is a little less than nine-tenths of a scale graduation below the next higher scale marking or a little more than one-tenth of a scale graduation above the next lower scale marking. Number 5 is a little more than two-tenths of a scale graduation above the next lower scale marking, number 4 is a little more than three-tenths, number 3 a little more than four-tenths, and so on, to the zero of the vernier which is a little more than seven-tenths of a scale graduation above the next lower scale marking. Thus, by these steps in the reading operation, we have determined that the reading is a *little more than* 30.27 inches.

(*e*) Up to the present stage of the discussion of this example, we have found that the correct reading is less than 30.280 inches and

more than 30.270 inches. If number 8 of the vernier had been in exact coincidence, the reading would have been 30.280 inches. If number 7 of the vernier had been in exact coincidence, the reading would have been 30.270 inches. If number 8 had been the same amount removed from coincidence as number 7, the reading would have been 30.275 inches. An inspection shows that number 8 of the vernier is closer to coincidence than is number 7. This latter observation suggests that the correct reading must, therefore, be 30.276 inches, 30.277 inches, 30.278 inches, or 30.279 inches. The selection to be made from among these readings will depend upon the judgment of the observer. This type of vernier will not reduce the necessity for approximation below the range of these values.

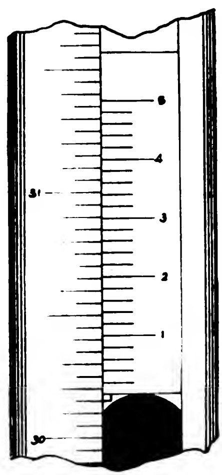


FIGURE 48.—Observed reading, 30.177 inches.

In this case it appears that 30.277 inches is a good approximation from among the four values included in the possible range.

(*f*) Next, we shall consider an example in which we use a vernier similar to those found on most barometers in use in the Army Air Forces Weather Service. The vernier shown in figure 48 has 25 divisions, equivalent in scale value to 24 scale divisions. Also, we note that the scale has been subdivided into graduations for each one-twentieth of an inch, i. e., to the nearest 0.05 inch. In the example of figure 48 we see that the zero of the vernier rests between the scale markings for 30.15 inches and 30.20 inches. If the fifteenth vernier division, which is marked "3" on the vernier, were in exact coincidence with some scale marking, then the zero of the vernier would be fifteen

twenty-fifths of 0.05 inch above the scale reading just below the zero of the vernier. In that case this reading would be 30.15 inches (as read directly from the scale) plus fifteen twenty-fifths, or three-fifths, of 0.05 inch, which would be 30.15 inches plus 0.03 inch, equaling 30.180 inches. The last digit would be added because we always record the observed reading to thousandths of an inch. If the twentieth vernier division, which is marked "4" on the vernier, were in exact coincidence with some scale marking, then the zero of the vernier would be twenty twenty-fifths, or four-fifths, of 0.05 inch above the scale reading just below the zero of the vernier. In that case the reading would be four-fifths of 0.05 inch. or 0.04 inch, above 30.15, equaling 30.190 inches. Thus each printed number on the vernier graduation, such as 1, 2, 3, 4 and 5, represent 0.01 inch, 0.02 inch, 0.03 inch, 0.04 inch and 0.05 inch, respectively. Since the interval between numbered graduations on the vernier is divided into five parts, each single small division of the vernier graduation is equivalent to one-fifth of 0.01 inch, or 0.002 inch. Thus the vernier shown in figure 48 will permit readings direct to the nearest 0.002 inch. Approximations can be made to the nearest 0.001 inch.

(*g*) Let us consider, again, the example shown by figure 48. Remembering that the scale is divided by markings for each 0.05 inch, we observe that the reading in this case is above 30.150 inches and below 30.200 inches. Looking along the vernier to find a vernier mark that is in coincidence or that is near coincidence, we see that no vernier marking is in exact coincidence. We do note that the marking nearest to coincidence is the third one above "2" on the vernier. That it is *above* "2" indicates that the true observed reading is more than 0.02 inch above 30.150 inches. Thus the correct reading must be somewhat more than 30.170 inches. A closer inspection of the vernier markings shows that the *third* short line above "2" is slightly too high to be in coincidence with its nearest scale graduation, and the *fourth* short line above "2" is slightly too low to be in coincidence with its nearest scale graduation. Since each short division on this vernier represents 0.002 inch, the third short line above "2" would be 0.006 inch above 30.170 inches, thereby indicating the observed reading to be 30.176 inches. Similarly, the fourth short line above "2" would be 0.008 inch above 30.170 inches, and if this fourth line had been in exact coincidence the observed reading would be 30.178 inches. But since the third line is too high for coincidence and the fourth line is too low, then true coincidence must be for some line that would occupy a position between them. Thus, by this method

of approximation, we arrive at the correct observed reading value of 30.177 inches.

f. Care of mercury barometer.—(1) *To move.* (*a*) A mercury barometer is a very delicate instrument and must be handled with great care. It should be transported, over short or long distances, only in an inverted position. Special care must be exercised in inverting a barometer to insure that no air is permitted to enter the tube. Before removing the barometer from the suspension hook of the barometer box, slowly operate the adjusting screw in such a manner as to raise the level of the mercury, both in the cistern and in the glass tube. Do not attempt to fill the tube completely with mercury. Since the top of the glass tube is obscured by the metal case, it is impossible to tell exactly when the tube is full, and a turn too much of the adjusting screw is almost sure to force the mercury through the joints of the cistern or even the pores of the leather bag and lead to very serious injury of the barometer. Raise the level of the mercury in the tube only until the top of the mercury column reaches the top of the opening in the metal casing.

(*b*) Next, remove the barometer from the suspension hook and centering ring, being careful to avoid subjecting the instrument to jarring or sudden movement. Hold the barometer firmly in both hands and lower the top of the instrument slowly, listening, meanwhile, for any slight sound or "click" that may be emitted from the top of the barometer. This sound, or "metallic click", as it is sometimes called, results from the mercury striking against the inner surface of the top of the glass tube. If the barometer is quickly inclined, the violent shock of the mercury against the top of the tube is sufficient to break the glass. The "metallic click" will be noticed when the barometer is inclined at about 45° at low-level stations. Continue lowering the top of the barometer slowly and when the instrument is in nearly a horizontal position, watch for the appearance of an air bubble at the cistern end. If the level of the mercury has been raised the proper amount before inverting of the tube is begun, this air bubble in the cistern will be about the size of a ten-cent piece. From the horizontal position, the barometer may be turned cistern-end up without any special precautions, and may then be handled with ease and safety.

(*c*) If the barometer is to be installed in a new position, it should be carried in the inverted position. At the point selected for the new installation, the instrument should be brought slowly and carefully to the normal vertical position. This must be done very slowly to

insure that the parts of the cistern are not subjected to undue strain. After the barometer has been brought to the vertical position, the cistern should be fitted into the centering ring and the top of the instrument fastened to the suspension hook. After the centering screws have been adjusted so as to hold the barometer truly vertical, the level of the mercury should be slowly brought to a position slightly below the ivory point.

(*d*) At stations with elevations of 3,000 to 10,000 feet or more above sea level, the top of the mercury column is a long distance from the top of the opening in the metal casing. At such elevated stations, it is not advisable, therefore, when it is desired to invert a mercury barometer, to operate the adjusting screw in one step until the column reaches nearly the top of the tube. A better plan is to raise the column

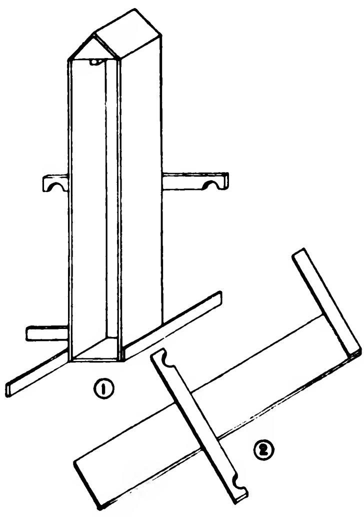


FIGURE 49.—Barometer packing box.

only 2 or 3 inches, then, while gradually inclining the instrument, continue to screw up the cistern until the column is about to disappear from view at the top. The object of this particular method is to avoid subjecting the cistern to the considerable hydrostatic pressure that occurs if the column is raised several inches above that which the air pressure itself is capable of supporting. At an elevated station the barometer must be in a much more nearly horizontal position to produce the "metallic click" than at sea level.

(2) *Preparing for shipment.*—Mercury barometers of the Fortin type must always be shipped in an inverted position. The box

container is of special design and must be prepared in advance. Figure 49 shows the details of this shipping box. Figure 49 ① shows the general features of the box, with the face board removed. The box proper is about 10 by 10 inches in cross section. It is firmly braced to a platform, as the sketch shows. The top end of the box is pointed to prevent its being rested on that end. A heavy staple is fixed to a cross piece in the top of the box and the barometer is suspended, inverted, by the attachment of a strong cord from this staple to the cistern of the barometer. After the barometer has been inverted, and before placing it in the packing box, it should be wrapped first in soft paper, then with a thick layer of cotton sheeting and an outer wrapping of heavy paper. Thus prepared, it is then suspended from the strong staple in the packing box, and completely and closely surrounded with good excelsior or cotton or similar elastic material. The face board must be screwed into place, not nailed. Handles are attached to the front and rear sides of the box so that it can be moved about in transit without the necessity for undue tilting and jostling about.

(3) *Cleaning.*—(*a*) The best possible care a barometer can receive is to be protected from accumulations of dust and left quite alone. In case the scale becomes somewhat dull and tarnished, it may be brightened by suitable polishing, but this is a delicate operation and should be avoided. The proper position of the scale has been fixed by the manufacturer in an effort to reduce the instrumental error. During the polishing operation there is always danger of shifting the position of the scale. If polishing is absolutely necessary, it should, therefore, be done with great care.

(*b*) After continued use, the mercury in the cistern of a barometer loses its brilliant surface and becomes coated with a film of oxide. This does not impair the barometer to any serious extent, and accurate readings can still be made with such an instrument. However, after several years exposure the mercury in the cistern may accumulate a considerable amount of flaky oxide on its upper surface, sufficient to make cleaning desirable.

(*c*) Great care must be used in cleaning the cistern and mercury, to insure that no permanent injury to the instrument results. One or more very clean, dry porcelain or glass cups should be provided. Avoid the use of damp, unclean, or metal vessels. Clean the cups by thorough washing in soap and water, and wipe dry with a clean cloth, finally polishing the vessel with tissue or similar soft paper. Provide, also, some pieces of clean cloth and sheets of tissue paper for clean-

ing the glass parts of the cistern, and a few small sheets of clean white paper about 6 by 6 inches for use in filtering the mercury. A most convenient arrangement for work while cleaning a barometer is to be seated in front of a desk with a drawer at the top and side partly opened. This provides a convenient corner in which the barometer can be rested in an upright position during the process.

(*d*) The barometer should be removed from its mounting box and carefully inverted in the manner described in paragraph 9*f*(1). Unscrew, with one hand, the portion of the cistern marked *s* in figure 41, grasping with the other hand only the narrow flange *r*. Next, separate the two wooden portions of the cistern marked *i* and *j*, by loosening the four screws uniting the split-ring clamp marked *l* and *m*. It is important that each screw be loosened a little in turn, otherwise an uneven strain may be thrown on some portion of the fragile wooden flange and chip out a piece. After loosening of each of the screws, one may be taken out entirely, and the whole system of split rings, still interlocked by the screws, will generally unfold from around the cistern. Sometimes a second screw must be removed before the rings may be withdrawn. If the split rings become separated, they should afterwards be united again precisely in the original relation.

(*e*) When removing the wooden piece *j* to which the leather bag is attached, lift it cautiously directly up from the part *i* so as not to spill the mercury, which is thereby exposed and should just about fill *i*. Hold a clean dry cup close under the flange of *i* and pour the mercury out steadily from the cistern. The mercury will not leave the open end of the barometer tube so long as the latter is not raised much above a horizontal position, and generally not then unless the opening is large and the tube shaken or jarred a little. Care must be taken to prevent the mercury from passing out of the tube. The barometer is then returned to its inverted position, and the remaining parts of the cistern are removed by loosening the screws *p*. Here again, each screw must be loosened a little in turn to avoid chipping or cracking the glass cylinder *f*. If a small globule of mercury remains in the glass cistern, allow the latter to rest in its position while the boxwood piece *i*, the metal flange *r* and the screws *p* are removed. Then, holding the glass cylinder in position with the fingers, empty what remains of the mercury in the cistern. In handling the little leather washers taken from parts of the cistern, avoid wrinkling or creasing them or otherwise changing their form, as any injury of this kind will probably result in leaks that cannot be prevented except by new washers.

(*f*) One of the most difficult and delicate parts of the process of cleaning is that about the wooden piece *g* and the ivory point. The deep and narrow annular space between the glass tube and the boxwood is generally covered with oxide of mercury which should be removed thoroughly by repeated wiping with clean cloths applied upon the ends of slender sticks, or by similar means. Care must be observed to remove all lint or dust that may be introduced during this step in the cleaning process, because, if these are allowed to remain about the parts of the cistern, they will find their way quickly to the surface of the mercury upon which they will float about to the detriment of accurate adjustments.

(*g*) Cleaning of the delicate ivory point should be accomplished with great care. The glass cylinder of the cistern should be washed with soap and water and rinsed freely with applications of clean water. After being dried with a clean soft cloth or tissue paper, this cylinder should not be touched with unprotected hands, especially on the inside. The remaining wooden portions of the cylinder should be wiped thoroughly clean and dry without touching the inside with the bare fingers. Shake out of the bag, so far as possible, every little particle of mercury that tends to remain in hidden corners and crevices. These little particles are very apt to be dirty and impure, and should, therefore, be removed.

(*h*) The several parts of the cistern should be replaced in the following order: First, the glass cylinder, with its leather washers, one at each end, is placed in position, followed by the boxwood piece *i* and the metal flange ring *r*. The three long screws *p* are next to be inserted and partially screwed up. While these various pieces are still loosely held by the screws, it is well to jostle the parts about a little and twist the ring and boxwood pieces upon each other and the glass cylinder. This will tend to bring the surfaces in the several joints nicely and uniformly into contact with each other, and adjust the ring *r* so that the screws are not even imperceptibly askew, but, when properly drawn up, produce a direct, uniformly distributed pressure. When the parts are thus adjusted, the screws *p* are to be tightened little by little, each one a little in turn after the others, until all are drawn down together equally tight. The observer must judge of this partly by the amount he has turned each screw and partly by the resistance it offers to further turning. It is not necessary that the screws be very tight. A judicious regard for these ideas constitutes, in part, the skill of the expert, and is the secret of perfect joints. To disregard them produces leaky joints and unequal pres-

sures that are apt to break the fragile boxwood flanges or crack the glass.

(*i*) The next step is to filter the mercury and restore it to the cistern. Using a small piece of clean paper, approximately 6″ x 6″, as suggested early in this paragraph, fold twice so as to provide four thicknesses 3″ x 3″. This may now be opened into a somewhat conical shape, with the inner closed corner of the fold constituting the bottom apex of the cone. The opened fold appears as shown in figure 50. A small bit should be clipped or pinched off the apex of the cone so as to provide an opening with a diameter of about one-eighth inch. Holding the cone over one of the clean cups previously provided, partly fill it with mercury. The mercury will flow slowly through the small opening of the cone, leaving the impurities of lead and oxide of mercury deposited along the sides of the paper. The cone should be kept well filled with mercury until all has been added. Do not allow

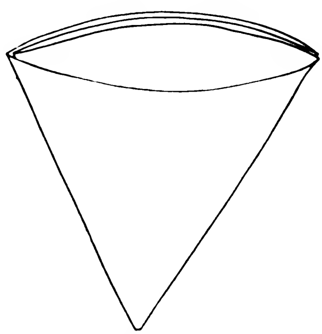


FIGURE 50.—Paper cone for filtering mercury.

the very last portion to pass through the filter. If the observer has only the supply of pure mercury taken from the barometer, economy must be exercised, but there should be no difficulty whatever in being able to filter and utilize the entire quantity of mercury originally in the barometer, and this is sufficient.

(*j*) The mercury may be refiltered from one clean cup to another until it is judged to be pure and clean. Next, it is to be filtered into the cistern, directing the little stream so as to strike against the wall of the glass cylinder to avoid inclosing small air bubbles near or upon the barometer tube. When the annular space between the glass tube and the boxwood piece *g* has been filled, and the mercury has risen to fill that part of the cistern inclosed by the glass cylinder, the open end of the tube should be filled completely and the mercury heaped into a button on the tip end. Then resume filling the cistern around the

boxwood piece *i* and the lower part of the tube. This button will unite with the mercury of the cistern as it rises around the tube, and the chances of inclosing air in the tip end of the tube are thus greatly reduced. In general, the cistern should be filled to the brim of the piece *i*. Before fitting the piece *j*, the leather bag should be pushed out from the inside and every effort used to detach and remove all dust or other foreign matter.

(*k*) In securing the clamp rings, the screws should be tightened a little at a time, and every precaution taken to insure a closely fitting and uniformly tight joint. When the screws are all tightened, the leather bag should be thrust up into the wooden piece *j* and *held there firmly* by the fingers while the barometer is gradually turned right side up. Watch to see if any leaks appear at any of the joints. The mercury column should not be lowered under any circumstances at this time. If a leak shows, it is probably due to uneven tightening of the joints, and in most cases it is better to loosen the whole joint and shift it a little before tightening again, rather than to strain the screws that are already tight.

10. Marine-type barometer.—*a. Purpose.*—The marine barometer, as the name implies, is specially designed for use aboard ship to measure the pressure exerted by the atmosphere.

b. Description.—(1) *General.*—Figure 51 shows several views of a marine-type barometer: ① is a detailed view of the barometer scales showing the vernier adjusted to the top of the mercury column; ② is an assembly view with a portion of the cistern walls cut away, showing the mercury in the cistern adjusted to the ivory point; and ③ is a cross-sectional view of the barometer cistern. The principal parts and features of this instrument have been labeled in figure 51. Detailed explanation of the parts mentioned above and indicated on the drawings will follow. The service to which a marine-type barometer is subjected is more severe than that required of a barometer mounted at a land station, due to the motion of the ship or vessel on which the instrument is mounted. Consequently, the general construction of this barometer is more rugged, and the individual parts are heavier than the corresponding parts of a barometer used at a land station. The design of this instrument embodies provisions for minimizing the effects produced by the rolling and pitching of a ship. In fact, the marine-type barometer can be used to good advantage at land stations where building vibrations or gusty and drafty conditions prevail.

(2) *Glass barometer tube.*—The glass tube, supporting the column of

mercury balanced by atmospheric pressure, has the following constructional features and dimensions as shown in figure 52. The length of the glass tube is approximately 34 inches. Its outside diameter is three-eighths inch. Along two-thirds of its length from the open end, the bore or inside diameter is about 0.08 inch. Along the remaining one-third of its length toward the sealed end, the inside diameter of the tube is about 0.25 inch. This means that the cross-sectional area

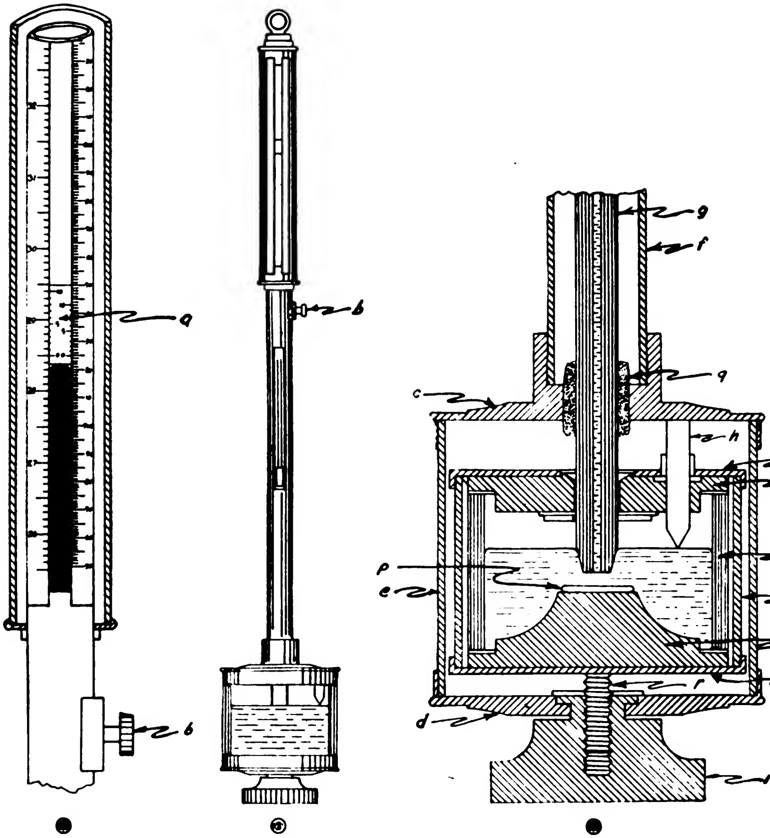


FIGURE 51.—Marine barometer.

of the top or expanded portion of the tube is approximately 10 times the cross-sectional area of the bottom portion of the tube. Consequently, a unit volume of mercury standing, for example, 1 inch high in the lower two-thirds of the tube would stand only one-tenth inch high in the upper one-third of the tube. It follows from this that any disturbance in the mercury starting at the open end of the barom-

eter tube and traveling upward toward the top of the tube, would be diminished ten times when it reached the expanded portion of the tube. The frictional effect of the mercury passing through the small portion of the barometer tube would also be a factor in reducing disturbances starting at the cistern. This upper expanded portion of the barometer tube is the working range over which measurements of the height of mercury above the cistern are taken. Therefore, it can be seen that disturbances in the mercury of a marine type barometer, caused by the motion of a ship, or sudden changes in pressure due to gusts of wind or drafts, will be greatly reduced as a result of the varying inside diameter of the barometer tube.

(3) *Metal barometer enclosure.*—The glass barometer tube is sup-

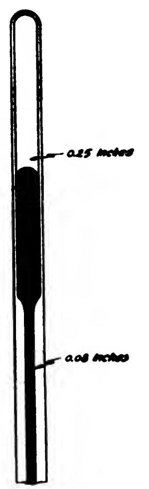


FIGURE 52.—Variable tube of marine barometer.

ported and enclosed in a brass tube seven-eighths inch outside diameter and three-fourths inch inside diameter. This part, marked *f*, is shown in section in figure 51③. The glass tube is supported in its metal case in a concentric position by leather bushings at the top and bottom. A cork bushing acts as an intermediate support near the center of the tube. A swivel mounting ring for supporting the entire barometer is mounted at the top of the metal tube. Two three-eighths inch slots, about 7 inches long, diametrically opposed, are cut into the metal case near the top. Through these slots the top, or upper third, of the barometer tube and the mercury column are exposed.

(4) *Barometer scales.*—On the left side of one of the openings in the barometer case mentioned above is a scale graduated in inches and

tenths of inches. On the right side of the same opening is a scale graduated in millimeters. This arrangement is shown in figure 51①. The illustration also shows a sliding vernier scale which moves up and down between the two fixed scales. This vernier scale is caused to move by turning the adjusting screw marked *b*. The motion is accomplished by means of a small rack-and-pinion arrangement inside the metal case. In order to protect the barometer scales against corrosion due to salt-laden air and salt spray, a cylindrical inclosure of glass is provided. This is shown in figure 51① and ②.

(5) *Attached thermometer.*—Since the temperature of the mercury in the barometer has a marked effect on the accuracy of its readings, it is necessary to determine this temperature accurately each time the barometer is read. For this purpose an accurate thermometer is mounted on the barometer case at about its center. There is a slot cut in the barometer case exposing the bulb of the thermometer to the air immediately surrounding the barometer tube. An inclosure protects the bulb from the surrounding outside atmosphere. With this arrangement it is possible to obtain the temperature of the mercury in the glass tube with good accuracy. This "attached thermometer" is graduated for both the Fahrenheit and Centigrade scales.

(6) *Cistern.*—(*a*) The reservoir of mercury in which the open end of the barometer tube is immersed is contained in an adjustable enclosure called the "cistern." This part of the marine barometer is shown in figure 51② and ③. The cistern is made up of two distinct assemblies. The unit which actually contains the reservoir of mercury is the movable part, which can be adjusted so that the level of the mercury in it can be brought to a fixed reference point with respect to the barometer scales. The other assembly is the frame of the cistern, which supports the movable reservoir and the adjusting screw.

(*b*) Referring to figure 51③, the parts of the cistern frame are lettered *c*, *d*, *e*, *h*, *i*, and *q*. The top flange *c* screws on to the barometer case *f*. The glass barometer tube *g* passes through *c* and is supported by a leather bushing *q*. The bottom flange *d* is supported from the top flange *c* by frame *e*. Frame *e* is in the form of a cylindrical tube from which most of the cylindrical surface has been cut out for visibility into the cistern, leaving but three narrow spokes for supporting flange *d* from flange *c*. This frame *e* screws into both flanges *c* and *d*. The adjusting nut *i* is fastened to the flange *d* in such a way that it can be rotated only. When the nut *i* engages the screw *r*, it can be seen that when *i* is turned one way or the other, the screw *r* will move up or down with respect to the stationary frame of the cistern. The moving,

or adjustable, part of the cistern which actually holds the reservoir of mercury, is mounted on the screw *r*. When properly adjusted, the surface of the mercury in this container should just touch the tip of the ivory point *h*. This mercury container is so constructed that the mercury comes in contact with no metallic parts whatsoever. Part *j* is a boxwood disc through which pass both the barometer tube and the ivory point sealed with leather bushings. Part *k* is shaped somewhat like the frustum of a cone and has a soft rubber cap *p*. A glass cylinder *l* separates the two boxwood disks through a pair of thin kid-leather washers, and these parts are held tightly together by a metal case consisting of two circular pieces, *m* and *n*, attached by screw threads to the metal cylinder *o*. This cylinder *o* is cut away in the same way that cylinder *e* is cut away, so that the level of the mercury within the glass cylinder may be seen. Part *n* is fastened to the screw *r*, and in this way the reservoir of mercury can be moved up and down and its level adjusted to the tip of the ivory point. When the mercury in the cistern is raised as high as possible, the rubber cap *p* is pressed against the open end of the glass barometer tube and effectively seals it. The barometer is always sealed in this manner when it is moved from one location to another.

(7) *Ivory point.*—The height of a column of mercury above the level of the mercury in a cistern will vary, due to changing atmospheric pressure. The useful range of a barometer is usually between about 26 and 32 inches. Therefore, it is not necessary to use a carefully graduated scale for more than the above range. Thus it will be seen in figure 51① that only a detached portion of a measuring scale need be used on a barometer. If this is the case, it is necessary to know where the zero end of the scale is located, and for this purpose a small inverted conical shaped piece of ivory is mounted on a stationary portion of the cistern on the upper flange *c*. This ivory point extends downward through the boxwood piece *j* into the inclosure containing the mercury reservoir. The very tip of the ivory point is said to be the zero end of the barometer scale. Since atmospheric pressure is constantly changing, the level of the mercury in the cistern will not always be the same, due to the rise or fall of the mercury in the barometer tube. It is, therefore, apparent that each time the barometer is read, it is necessary to adjust the level of the mercury in the cistern to the tip of the ivory point, or zero end of the barometer scale.

c. *Care of marine type barometer.*—(1) *To move.*—Since the barometer is a precise and carefully constructed instrument, it can be damaged easily or made unfit for accurate service by rough or improper handling.

Whenever it is required that the barometer be moved from one location to another, it should always be held in an upright and vertical position. Before the barometer is removed from its suspension hook, the cistern should be raised as far as possible with the adjusting knob, so that the rubber pad on the lower boxwood piece *k* will seal the open end of the glass barometer tube. It is impossible to fill the barometer tube completely with mercury by raising the cistern, but the level in the glass tube will be raised appreciably. The barometer may now be removed carefully from its suspension hook and moved to the desired new location. During actual handling of the barometer, all motions should be made with much care in order to minimize the strain of mercury acting against glass parts. After the barometer has been installed in its new location, the level of the mercury in the cistern should be lowered to a point just below the tip of the ivory point. The barometer is now ready for use.

(2) *Preparation for shipment.*—Figure 49 shows the type of box that should be used for shipping a mercury barometer. Its features provide stability for the barometer in a vertical position and eliminate necessity for nailing down the cover, which precludes any jarring or shock due to this process. After a box has been prepared, the mercury in the cistern should be raised as high as possible so that the barometer tube is closed by the rubber pad. Then it may be removed from its mounting to be wrapped. The first covering should be of soft paper; next, a layer of sheet cotton; and finally, a covering of heavy wrapping paper. The barometer is then suspended from its mounting ring in the wood box, and the empty space in the box is filled with excelsior or other packing material. The box cover is then screwed into place, using wood screws, and the barometer is ready for shipment.

11. Fixed-cistern barometer.—*a. Purpose.*—The fixed-cistern barometer is used to measure accurately the pressure exerted by the atmosphere.

b. Description.—(1) *General.*—Unlike adjustable-cistern barometers, this type of instrument measures the height of a column of mercury above a cistern by means of a scale which does not represent actual units of length. The scale, fixed to the frame of the barometer, is compensated for the movement of the level of the mercury in the cistern due to changing atmospheric pressure. Rugged constructional features of this barometer, and its simplicity of operation, make it suitable for use as a marine instrument aboard ship.

(2) *Contracted barometer scale.*—The relation between the true length of a column of mercury and the observed position of its top in

a fixed-cistern barometer depends on the relation between the inside areas of the cistern and the barometer tube. When this relation has once been worked out, it is then necessary, in reading the barometer, to observe only the position of the top of the column, and to apply a "correction for capacity." As the correction for capacity in barometers with fixed cisterns remains the same so long as the quantity of mercury in the barometer and the inside areas of the tube and cistern are unchanged, it will not be necessary to apply a capacity correction to every reading made, provided a scale is used on the barometer having all its divisions modified by just the proper amount to compensate for the capacity effect. For example, suppose the top

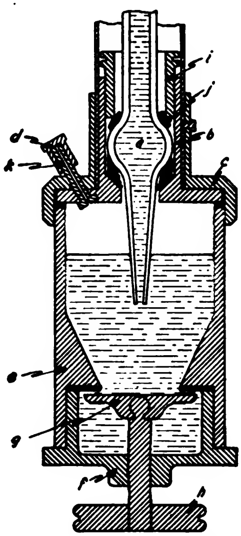


FIGURE 53.—Fixed-cistern barometer.

of a column of mercury in a barometer is just 30 inches above the cistern level. Assume the sectional area of the barometer tube at the top is one-fiftieth as great as that of the cistern. Imagine the column of mercury in the tube to rise 1 inch. It will appear to become 31 inches high, but when the column rises 1 inch, the mercury in the cistern falls one-fiftieth of an inch, and thus the real height of the column must be $31\frac{1}{50}$ inches. From this it may be said that each inch of the scale represents $1\frac{1}{50}$ inches of change in the real height of the mercury column. If a special scale is prepared, having the spaces representing inches, each one fifty-first part of an inch shorter than a true inch, then readings of this assumed barometer on such a scale will indicate the true height of the column of mercury above the

cistern. It is assumed that the sectional areas of the tube and cistern are uniform, and that the scale is adjusted to a proper distance from the cistern. By methods of calibration, manufacturers are able to construct scales and barometers of great accuracy in accordance with the above principles, and they are very convenient to use.

(3) *Fixed cistern.*—Figure 53 shows a cross section of the fixed cistern. A special feature of the barometer is the means provided for filling the cistern and tube with mercury so that the barometer can be shipped safely from place to place. To fill the cistern with mercury, the barometer is first very carefully and gradually inclined and inverted. When fully inverted, there is just enough mercury to fill the cistern to the throat of the contracted portion at *g*. Upon screwing up of the milled head *h*, the plate *g* closes against the bottom of the cistern and completely encloses the mercury, with a small amount of free space left for expansion. If the barometer is now turned erect, the mercury column cannot descend unless the screw *h* is loosened, whereupon the mercury would flow into the previously unoccupied space below the plate *g* and would permit the column to resume its normal level. The barometer tube has an expanded bulbous section, shown at *a*, for the purpose of securing the tube in a fixed position with respect to the cistern. The packing *j* is held compressed about *a* by the locking bushing *i*. The vent *k* is provided for allowing free action of the atmospheric pressure on the surface of the mercury in the cistern. The cap *d* is put on and securely screwed down when the barometer is inverted and prepared for shipment.

(4) *Capacity correction.*—It is evident that by sliding the scale of a fixed-cistern barometer up or down, it can be so adjusted that a reading at some one point is just right. For example, place the 30-inch mark so that when the top of the column is at this mark, the surface of the mercury in the cistern is just 30 inches below. If the sectional area of the tube is a, and that of the cistern is A, then, when the mercury column in the tube rises one scale division, the fall in the cistern will be only $\frac{a}{A}$ part of one division. That is, the correction for a scale reading just one division above the 30-inch mark is $+\frac{a}{A}$ divisions; for a reading two divisions above, the correction is $+2\frac{a}{A}$, etc. This, expressed in a mathematical formula, becomes:

$$\text{Correction: } C=(h-R_o)\frac{a}{A}$$

in which R_0 is the reading at which the correction is zero and h is the observed reading, uncorrected for temperature.

c. Preparation for shipment.—The fixed-cistern barometer may be shipped in its normal vertical position. First, however, the barometer tube and cistern must be completely filled with mercury. This is done as described in paragraph 11*b*(3). The barometer may then be wrapped and suspended in a packing box in the same manner as outlined for the Fortin-type and marine-type barometers previously described.

d. Care.—Since the accuracy of this type of barometer is dependent on having a correct amount of mercury in its cistern, it is important that no leaks develop in the cistern. It will never be necessary to dismantle this type of barometer to clean the mercury, as a perfectly clean surface of mercury is not essential for reading or setting. In the event that a barometer tube is broken, it will generally be necessary to replace not only the tube but also the barometer scale, since it is obvious that it would be difficult to find another tube so nearly the same size as the old one that it could be used with the old scale.

12. Barograph.—*a. Purpose.*—The barograph is a sensitive recording-type instrument used to obtain a continuous and automatic record of atmospheric pressures exerted at a given location over a period of time.

b. Description.—(1) *General.*—The essential units required for a barograph are, first, an operating element which is sensitive to changes in atmospheric pressure, and second, a reliable and accurate clock mechanism. The motion derived from an operating element, which either expands or contracts due to the action of atmospheric pressure, is amplified or increased by means of a system of levers, and is transmitted to a pen which leaves a mark on a chart graduated in suitable units of pressure. The clock mechanism is used to move the chart under the pen. The result of such an arrangement is a two-dimensional trace indicating the value of the atmospheric pressure at any time during the period covered by the chart. The "sylphon" cell is a well-known type of operating element which is sensitive to changes in atmospheric pressure. In figure 54 is shown a sketch of a barograph mechanism with all the principal parts labeled.

(2) *Sylphon cell.*—(*a*) Figure 55 shows the barograph operating element or sylphon cell, in a cross-sectional view. It is in a form that may be described as a cylinder, made of thin, hard brass, silver plated, having a very thin but deeply corrugated surface. It can be seen that this cell may be either expanded or compressed considerably along its central axis. This sylphon cell is made sensitive to

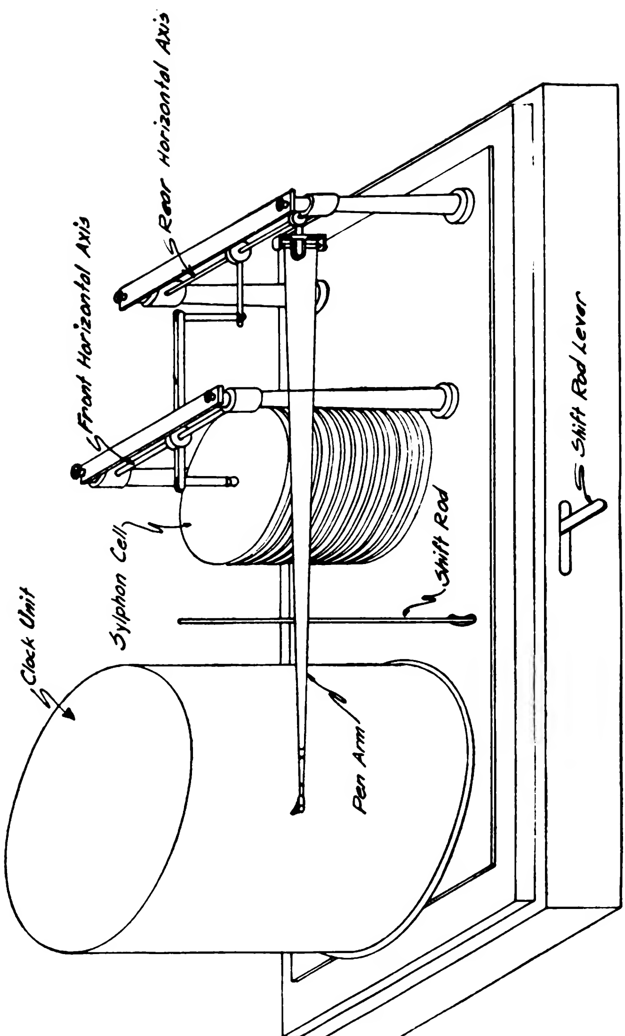


FIGURE 54.—Barograph.

atmospheric pressure by exhausting most of the air from its interior. A strong coil spring centrally located inside the cell prevents the element from collapsing due to the outside atmospheric pressure. Thus, the force due to the atmosphere's weight is balanced by a spring in much the same manner that a weight is balanced by a spring scale. It is now only necessary to attach a pointer to the cell so that the amount of compression or expansion of the coil spring is indicated when the atmospheric pressure increases or decreases.

(*b*) It is clear, then, that an increase in atmospheric pressure will tend to compress the sylphon cell and a decrease in atmospheric pressure will allow the cell to expand. On the barograph, one end of this element is fixed and the other end is free to move and to operate a pen through a system of levers. The arrangement is such that a decrease in pressure will cause the pen arm to drop, while an increase

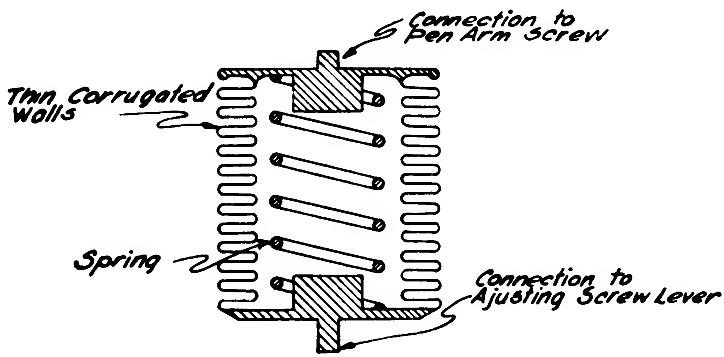


FIGURE 55.—Cross section of sylphon cell.

in pressure will cause the pen to be lifted. The lever system is so arranged that a pressure change is shown on the barograph chart with a movement of the pen at the same rate that the mercury in a mercury barometer rises or falls. In other words, if the mercury in a barometer rises 1 inch during a given period, the pen point on the barograph will also rise 1 inch on the chart. Unlike the barometer, however, the barograph does not require temperature corrections. It is a fact that metals weaken and lose resilience when heated, and consequently a weakening of the spring in the sylphon cell could be expected when the barograph is operating under high temperatures. Such a condition would call for a correction applied to the readings thus obtained. However, the amount of air left in the sylphon cell is so calculated that its expansion due to heat will cause an internal pressure in the cell which just balances the weakening of the spring

caused by heating. In this way, errors due to high temperatures affecting the parts of a barograph are counteracted.

(3) *Adjusting screw.*—On the right end of the barograph frame is a milled-head screw which is used to adjust the fixed end of the sylphon cell. This adjustment in turn sets the pen point of the instrument to any desired pressure on the chart. Figure 56 shows the mechanical arrangement which permits the fixed end of the sylphon cell to be adjusted.

(4) *Pen arm.*—The constant-pressure-type pen arm used on the barograph is similar to that used on the thermograph, the major difference being the length. On the barograph the length of the

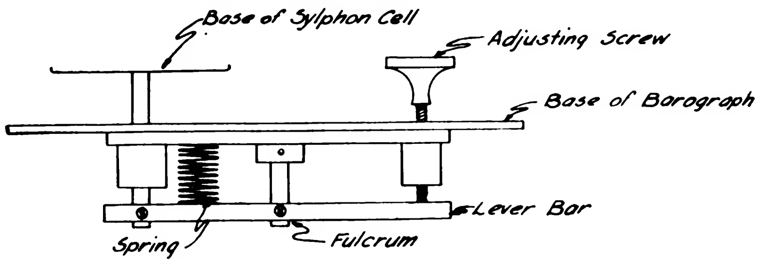


FIGURE 56.—Adjusting screw.

pen arm is 7 inches. See paragraph 7*b*(4) for full details of the thermograph pen arm.

(5) *Pen.*—Paragraph 7*b*(3) fully describes the pen used on the thermograph, which is exactly the same as used on the barograph.

(6) *Clock unit.*—Paragraph 7*b*(2) fully describes the clock unit used on the thermograph, which is the same as used on the barograph except that for the barograph there is no provision for converting the unit to daily rotation of the drum.

c. Installation.—The primary care in choosing a suitable operating position for the barograph is that the instrument should not be subjected to jarring and vibration. If such a location cannot be found, it will be necessary to mount the instrument on sponge rubber pads or light coil springs, to remove the effects of jarring. Although the barograph is compensated for high temperatures, it should not be exposed to excessive heat or sudden changes in temperature. It should never be exposed to direct or reflected sunlight. Care should also be taken that the instrument is not located in an area subject to drafts or sudden movements of air.

d. Reading the barograph.—The barograph chart is graduated in inches of mercury at actual scale. The usual range for barograph

charts is from 28 inches to 31 inches. Each inch is subdivided into 20 divisions, making the smallest graduation equal to 0.05 inch. When reading the barograph, it is necessary to obtain a reading to the nearest 0.01 inch. Therefore, in order to do this, the location of the barograph trace must be estimated to the nearest one-fifth of the smallest graduation.

e. Care.—(1) *Clock unit.*—The barograph clock unit is similar to

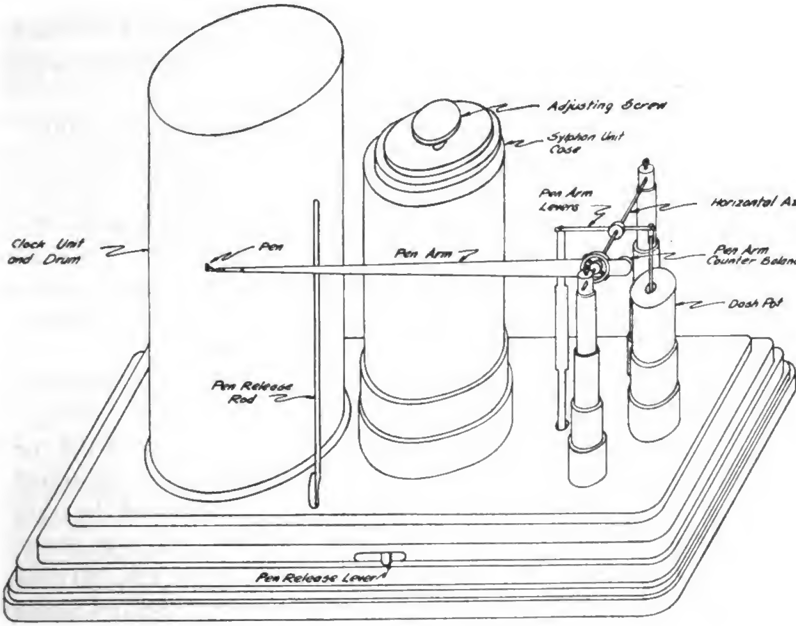


FIGURE 57.—Microbarograph.

that used in the thermograph, and full instructions concerning its care are given in paragraph 7*e*(1).

(2) *Barograph time error.*—The barograph is subject to the same time error which occurs in the thermograph. The method of keeping the barograph operating on correct time is the same as that discussed in paragraph 7*e*(2).

(3) *Pen.*—The pen used on the barograph is the same as the thermograph pen and is fully discussed in paragraph 7*e*(3).

(4) *Pressure error.*—At the time of changing the barograph chart or record sheet, the barograph should be adjusted so that the new record starts with the true station pressure as obtained from a reading of the mercury barometer. In adjusting the pen to the proper

pressure, the base of the barograph should be lightly tapped in order to settle the various moving parts and to take up any lost motion in the lever linkages. The pen should rest at its proper setting after the instrument has been tapped.

(5) *Bearings.*—The bearings supporting the front and rear horizontal axes (shown in figure 54) should be kept free of dust and lubricated occasionally with a drop or two of clock oil.

13. Microbarograph.—*a. Purpose.*—The microbarograph is a very sensitive recording-type instrument used to obtain a continuous and automatic record of the atmospheric pressures exerted at a given location over a period of time.

b. Description.—(1) *General.*—The microbarograph is similar in many ways to the barograph. However, some of the refinements which have been incorporated in it make it a much more useful instrument than the barograph. An expanded open-scale record sheet and a correspondingly greater pen-arm movement for a given pressure change, make it easier to obtain a more accurate pressure reading or pressure tendency. Figure 57 shows the microbarograph with its cover removed and its essential parts labeled.

(2) *Sylphon unit.*—The sylphon unit of the microbarograph is made of two sylphon cells, such as that used on the barograph. They are fastened together, one over the other, and are suspended in the metal cylinder shown in figure 57. The top of the upper cell is attached to an adjusting screw at the top of the mounting cylinder, and the bottom of the lower cell is free to move with changes in atmospheric pressure. The pen arm is, therefore, connected to this lower cell through a system of levers. Adjustment of the pen point to a desired pressure reading on the chart, is accomplished by turning the adjusting screw on top of the metal cylinder. The combined motion of the two sylphon cells working together provides a greater movement of the pen arm for a given pressure change. This permits the use of a record sheet with an expanded scale and, accordingly, more accurate readings of pressures and pressure tendencies may be obtained. The lever system from the sylphon unit to the pen arm is so adjusted that the pen moves 2½ times the amount that mercury moves in a barometer for a given pressure change.

(3) *Pen arm.*—The constant-pressure-type pen arm used on the microbarograph is similar to those used on the thermograph and barograph. One difference is that the length of the pen arm for the microbarograph is 7.625 inches. The design of the tilted pivot which holds the pen on the record sheet with constant pressure is somewhat different

from the design used on the other recording instruments mentioned. Figure 58 shows the details of this item.

(4) *Pen.*—The pen used on the microbarograph is the same as used on the thermograph, and is fully described in paragraph 7*b*(3).

(5) *Clock unit.*—The microbarograph clock unit is similar to the one used on the barograph. Since the microbarograph chart is expanded and is larger than the barograph chart, the microbarograph drum is considerably longer than either the thermograph or barograph drum. The time element is also expanded, and the microbarograph drum makes one complete revolution in 4 days. See paragraph 7*b*(2) for full details of the clock mechanism.

(6) *Dash pot.*—Since the microbarograph is a very sensitive instrument, some provision must be made to minimize disturbances due to mechanical vibration and accidental jarring. For this purpose an extension of the pen arm lever is attached to a device known as a "dash pot." It consists of a piston with a small pinhole in it, operating in a

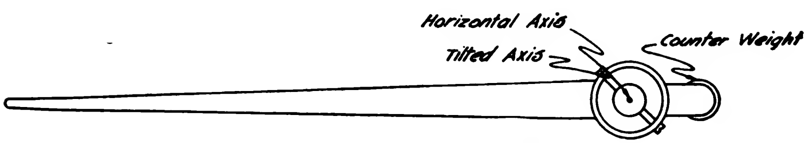


FIGURE 58.—Microbarograph pen arm.

cylinder full of liquid. When a moving force is applied to the piston, its motion will be retarded by the friction of the liquid in the cylinder being displaced through the small hole in the piston. Figure 59 shows a cross-sectional view of the dash-pot mechanism which is used on the microbarograph. It can be seen that this device will greatly reduce the effect of disturbances that may be transmitted to the pen arm of the microbarograph. At the same time there is no interference with the motion of the pen arm due to changes in atmospheric pressure, as this motion takes place slowly and gradually and the retarding effect of the dash pot for such slow movements is negligible.

c. Installation.—When a microbarograph is being installed, the same care and precautions should be taken as for the barograph. This matter is fully discussed in paragraph 12*c*.

d. Reading microbarograph.—The microbarograph chart is graduated in inches of mercury at 2½ times actual scale. The range of the chart is 2½ inches of mercury. However, an actual range, in inches, such as 28 inches to 30 inches, is not placed on the chart. This is left to be filled in at the station where the instrument is in operation. In this way the same chart or record sheet may be used at any location where

the pressure range may be in the high or low pressures. Since the microbarograph chart is expanded to 2½ times the scale of the barograph chart, the smallest pressure graduation on this chart will be 0.02 inch of mercury. Pressure readings are taken to the nearest 0.01 inch, and pressure tendency readings are estimated to the nearest 0.005 inch.

e. Care.—(1) *Clock unit.*—The microbarograph clock unit is similar to that used in the thermograph, and full instructions concerning its care are given in paragraph 7*e*(1).

(2) *Microbarograph time error.*—The microbarograph is subject to the same time error which occurs in the thermograph. The method

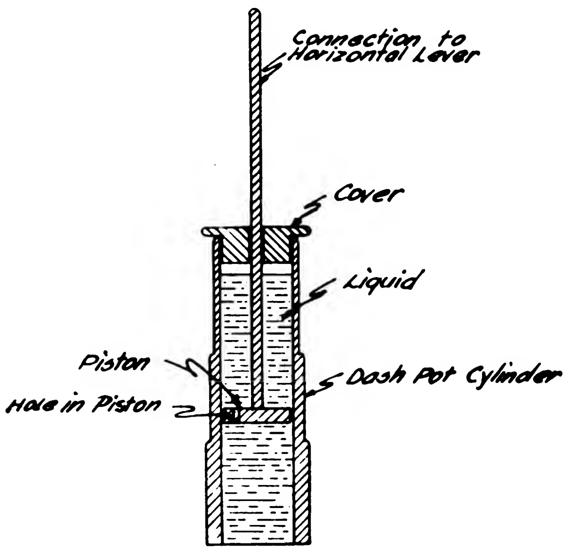


FIGURE 59.—Cross section of dash pot.

of keeping the microbarograph operating on correct time is the same as discussed in paragraph 7*e*(2).

(3) *Pen.*—The pen used on the microbarograph is the same as the thermograph pen and is fully discussed in paragraph 7*e*(3).

(4) *Pressure error.*—The microbarograph is subject to the same pressure error as the barograph. To insure that the microbarograph will record the correct pressures, the procedure is the same as described in paragraph 12*e*(4).

(5) *Dash pot.*—Before the instrument is placed in service, the dash pot must be filled with a special liquid provided for the purpose. When the dash-pot cylinder is filled, the level of the liquid must not be higher than within one-half inch of the top. The piston should be

removed before the liquid is poured into the cylinder, so that no air bubbles will collect under it. It is obvious that air trapped under the piston of the dash-pot mechanism would tend to give the pen arm added displacement, due to expansion of the air bubbles with an increase in temperature. Such a condition would cause a considerable error in pressure readings. Also, the piston should never be in contact with the surface of the liquid in the dash pot, as surface tension would tend to deflect the pen arm from a true pressure reading. The fluid used in the dash pot of a microbarograph is hygroscopic and tends to collect moisture from the atmosphere. At times there may be

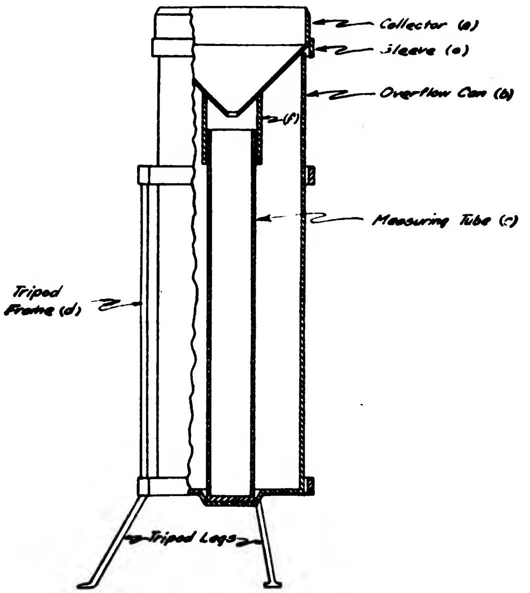


FIGURE 60.—Eight-inch rain and snow gage.

enough moisture collected in the dash pot to raise the level of the liquid to the top of the cylinder. If this should happen, the excess liquid should be removed with an eyedropper.

14. Eight-inch rain and snow gage.—*a. Purpose.*—The 8-inch rain and snow gage is used to measure the amount of precipitation falling at a station, either as rain or snow.

b. Description.—(1) *General.*—Figure 60 shows the component parts of the 8-inch rain and snow gage in a partial section view of the instrument. The tripod *d* is made of iron, painted with black asphaltum; the collector *a*, the overflow can *b*, and the measuring tube *c* are all made of copper or brass. Since this rain gage is exposed to

every kind of weather, it should be impervious to corrosion and oxidation. Consequently, the various parts are of materials which are corrosion resistant and will endure long periods of exposure to weather without deterioration. The measuring stick, shown in figure 61, completes the 8-inch rain and snow gage assembly.

(2) *Collector.*—The top ring of the collector is made of seamless brass tubing, 8 inches inside diameter, with the outside beveled to a sharp knife edge at the top. This is done to define sharply the area of collection, and to discriminate against borderline drops of rain which might roll or splash into the collector due to a wide and blunt edge. The funnel portion of the collector is of copper and has a five-eighths inch opening at the apex, a hole large enough to pass the measuring stick. A copper band *e* forms a sleeve which covers the opening where the collector rests on the overflow can. This prevents the entry of rain into the overflow can except by way of the collector. In the

FIGURE 61.—Measuring stick.

same way, *f* is a sleeve which fits over the measuring tube *c* and holds it centrally in the overflow can.

(3) *Overflow can.*—The overflow can *b* is made of copper, has an inside diameter of 8 inches, and is 24 inches deep. This serves as a container for the water which overflows from the measuring tube *c* after it is filled. There is a circular concentric depression in the bottom of this can in which the measuring tube normally rests.

(4) *Measuring tube.*—The measuring tube *c* is made of seamless brass tubing, 2.53 inches inside diameter, and 20 inches deep. The cross-sectional area of this tube is one-tenth that of the collector and the overflow can. Consequently, if enough rain fell through the collector to rise to a depth of 1 inch in the overflow can, the same amount of water would rise to a depth of 10 inches in the measuring tube. Since the measuring tube is exactly 20 inches deep, it will measure 2 inches of rainfall.

(5) *Measuring stick.*—The measuring stick, used for measuring the depth of rain catch, is made of red cedar wood. It is nine-sixteenths inch wide, one-eighth inch thick, and 24 inches long. The reddish color permits the water mark to show clearly, and the wood texture does not permit rapid capillary action, thus making the water line clearly defined. The stick is graduated in tenths of an inch. Since the cross-sectional area of the measuring tube is one-tenth the area of the collector, the depth of rain is multiplied by 10 as it is directed

into the measuring tube. Thus, as the measuring stick is used only in the measuring tube, each of the one-tenth inch graduations thereon indicates only one one-hundredth inch of rainfall over the horizontal section of the collector. When used for measuring the depth of snowfall, the graduations of the measuring stick are used directly without conversion, remembering that each interval between markings is one-tenth inch.

c. Installation.—In general, rain gages should be placed in the open, away from tall obstructions such as high buildings, tall trees, etc. Low obstructions, such as bushes, walls, or fences, if not appreciably higher than the rain gage and not closer to the gage than the height of the obstruction, are actually beneficial in breaking up the force of the wind which tends to carry away rain that ordinarily would fall into the collector. The gage should be installed securely so that the instrument cannot be blown from its support. Provision is made in the tripod support for the employment of heavy screws or spikes for this purpose. Rain gages should be installed so that they are as level as possible, since the circular area of the collector will decrease as the instrument is tilted and the projection of the circle becomes elliptical. Level ground exposures should be chosen for the rain gage whenever possible, but if it is mounted on a roof, the roof should be level and the gage should be placed centrally.

d. Use.—The amount of rainfall is measured to the nearest 0.01 inch by inserting the measuring stick slowly into the measuring tube through the opening in the collector until it strikes the bottom of the measuring tube. The stick is held in this position for a moment and withdrawn. Then it is read to the highest graduation which has become wet. In event that the rainfall measurement shows less than 0.01 inch, this should be recorded as a "trace." If more than 2 inches of rain have fallen, the measuring tube will have overflowed and the excess water will have found its way into the overflow can. The water in the measuring tube is emptied and 2 inches of rain are accounted for. The remaining water in the overflow can is then measured in the measuring tube and added to the 2 inches already recorded. In freezing weather, the measuring tube and the collector are removed from the gage assembly and kept inside. To measure the amount of snow, sleet, or hail that has fallen into the overflow can during freezing weather, take the overflow can containing the precipitation inside and add a measuring tube full of hot water. When the snow or sleet has melted, pour off a measuring tube full of water, and measure the remainder of the melted snow or sleet as described above to obtain

the "water equivalent." Since snow is usually blowing or drifting with the wind, a more correct or accurate method of measuring the water equivalent is to invert the overflow can in an average depth of snow and, by slipping a thin plate in under the can, pick up the snow and melt it in the manner described above.

e. Care.—The lower funnel portion of the collector and the measuring tube are subject to damage during freezing weather. Accordingly, both the collector and the measuring tube should be removed from the overflow portion of the gage and stored inside the station during all freezing weather. The overflow can should be cleaned regularly to keep out any collection of sediment or other material that may have fallen into it. The whole rain-gage assembly should be scoured at intervals when required. If the tripod begins to show rusty spots, these should be painted over with a good grade of asphaltum paint.

15. Tipping-bucket rain gage.—*a. Purpose.*—The tipping-bucket rain gage is designed as an electrical transmitting rain gage, to be used in conjunction with the quadruple register, for the purpose of making remote indoor records of the amount and rate of rainfall.

b. Description.—(1) *General.*—The tipping-bucket rain gage consists of a collector ring with funnel, an overflow reservoir, and a tipping bucket, all mounted on a tripod support. A special check measuring tube and a measuring stick are furnished with each instrument.

(2) *Collector.*—The top ring of the collector *a* (fig. 62) is made of seamless brass tubing, 12 inches inside diameter, with the outside beveled to a sharp knife edge at the top. The funnel portion of the collector is of sheet steel, and it has a one-quarter inch opening at the apex fitted with a short nozzle *f*. The band *e* forms a sleeve which covers the opening where the collector rests on the overflow reservoir, preventing entry of rain into the instrument except through the collector.

(3) *Overflow reservoir.*—In figure 62, *b* indicates the overflow reservoir, which is made of sheet steel. It is equipped with an inspection door *g*, through which the tipping-bucket mechanism may be adjusted. There is a protective canopy over this door which prevents rain from entering into the overflow reservoir. The bottom of the overflow reservoir is funnel-shaped and has a spigot at its apex for drawing off the water which has been collected. Both the overflow reservoir and the collector are usually protected by aluminum paint.

(4) *Measuring tube.*—The measuring tube provided with the tipping-bucket rain gage is a cylindrical brass vessel with an inside

diameter of 3.8 inches. Its cross-sectional area is one-tenth the collecting area of the collector. Thus, as water is drawn from the overflow reservoir into this measuring tube for check measurements, its depth is multiplied 10 times, compared to the depth of rainfall as it would be over the horizontal collecting area. The tube is 10 inches deep and when full would contain an amount of water 1 inch deep over the circular horizontal collecting area of 12 inches diameter.

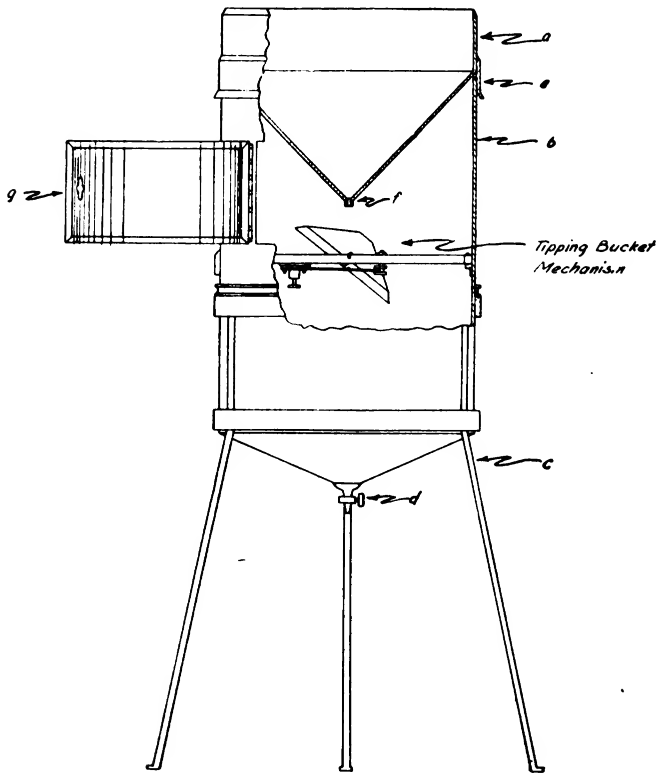


FIGURE 62.—Tipping-bucket rain gage.

(5) *Measuring stick.*—The measuring stick used with this instrument is exactly the same as used with the 8-inch rain gage and is fully described in paragraph 14*b*(5).

(6) *Tipping bucket.*—(*a*) The tipping bucket is the mechanism which permits recording of the amount and rate of rainfall. Figure 63 shows the tipping-bucket unit removed from the rain gage. The

bucket *a* is a symmetrical container having a separator baffle *l* at its center. This bucket is mounted between the two framed bars *b* on the pair of trunnions in such a manner that it can be balanced in a horizontal position, and also, if the bucket is rotated a small amount past the horizontal, it will continue to turn, due to its unbalanced weight, until it is stopped by the projection *e* striking the frame bar. The tipping-bucket trunnions rest in a pair of bearing holes provided in the frames *b*. In figure 63 a slot *i* on the front frame bar provides a housing for the front end of the bucket axis. There is a hole drilled into the side of the rear frame bar which provides a housing for the rear end of the bucket axis. A pair of adjusting screws *h* is provided to keep the tipping bucket centered in the frame. This mechanism is mounted in the rain gage just under the collector funnel, so that the rotating axis of the bucket is directly under the nozzle *f* of the collector (fig. 62). As water from the collector is directed into one section of the bucket through the nozzle, the bucket will become un-

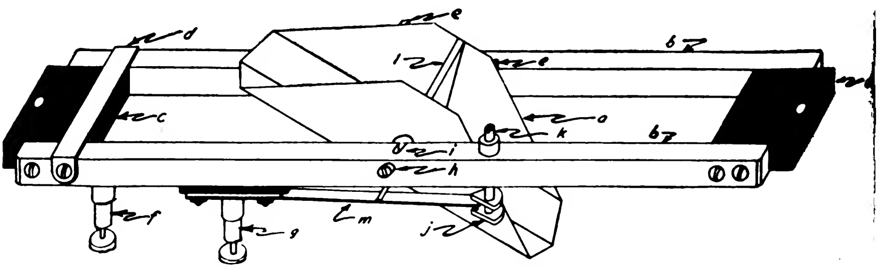


FIGURE 63.—Tipping bucket.

balanced when this section contains just that amount of water which is sufficient to cover the collector area to a depth of 0.01 inch. At this time, the bucket will rotate about its axis, emptying the collected water into the overflow reservoir and, at the same time, bringing the other section of the bucket into position under the collector to receive the succeeding rainfall. It requires approximately three-tenths of a second for the bucket to complete its motion, once the state of unbalance is established. During rapid rates of rainfall, an appreciable amount of water will enter through the collector before the next compartment is in position. Thus, under such conditions, the recorded amount will be less than that collected in the overflow reservoir.

(*b*) The provision for automatic recording of the rate and amount of rainfall can be understood by reference to figure 63. The binding posts for attachment of the wires leading from the recorder are shown

at *f* and *g*. Note that binding post *f* is connected electrically direct to the metal frame of the tipping-bucket assembly. Binding post *g* is insulated from this frame by strips of insulating material. As the bucket tips in either direction, a cam, which is not shown in this figure but which is located on the bottom of the front edge of the bucket, depresses the long spring contact arm *m*, making contact with a small platinum contact at *j*. From here the circuit runs through the vertical rod *k* to the frame and back to the other side of the circuit through binding post *f*. The contact at *j* is made shortly after the bucket begins to tip. As the tip is completed, the cam moves to such a position as to release the spring arm *m* and the circuit is opened at *j*.

(*c*) In order to insure continuous operation of the recording circuit if the contact electrode *j* should become fouled, an auxiliary cam and spring contact are located on the rear side of the bucket and frame. The circuit through this auxiliary arrangement would be from binding post *g* through spring arm *m* to the front cam, through the bucket to the rear cam and spring, to the rear side of the frame, through connecting bar *d* to binding post *f*. The hard rubber blocks *c* are used to insulate the frame of the tipping-bucket mounting from the walls of the overflow reservoir. The electric circuit wires are led from the binding posts *f* and *g* through a shielded aperture in the side of the overflow reservoir.

c. Installation.—The same rules that apply to installation of the 8-inch rain gage apply to installation of the tipping-bucket rain gage and are fully discussed in paragraph 14*c*.

d. Care.—(1) The tipping-bucket rain gage is used for measurement of rainfall only. During freezing weather, the tipping bucket should be removed and stored in the station and the collector should be covered with heavy canvas which is stretched tightly and tied securely to several points about the support rings. It is also good practice to keep the drain spigot turned to the open position.

(2) The frame which holds the tipping bucket must always be maintained in a perfectly level position. This should be checked and adjusted with the aid of a small spirit level at least once during each month. Adjustments can be made through the attachments of the hard rubber insulating blocks *c* to the walls of the overflow reservoir.

(3) The front and rear bearings of the tipping-bucket axis must be maintained clean and freely operating. This can be done readily by removing the bucket, wiping off the ends of the axis with a clean soft cloth, and cleaning the slot *i* and the axis bearing in the rear bar *b* by

use of a small piece of clean cloth wrapped about a small wood splinter or match stick. Before reinstalling the bucket, a small drop of watch oil should be placed in each bearing. This feature of the care of the instrument should be accomplished once during each week.

(4) The electrical contact *j* and the spring contact on the rear frame bar should be cleaned weekly. This should be done by using a piece of fine emery cloth.

(5) The cams on the front and rear sides of the bucket must be kept clean so that they will ride freely over the projections on the contact springs. These cams may be cleaned when the bucket is removed for the purpose of cleaning the bearings.

(6) At least once during each month of the nonfreezing season the bucket mechanism should be tested for accuracy in recording. This is done by placing a known amount of water in the measuring tube and slowly pouring this into the collector. The tipping of the bucket back and forth should be observed carefully to see that it is properly balanced. Sometimes it will be observed that one compartment of the bucket will require more water to cause an unbalance than the other. This suggests that the frame is not level, and correction should be made at once. Further, after the full amount of water has been poured into the collector, the automatic record should be checked to see how closely the record agrees with the known amount of water used. Usually the recorded amount will be slightly less than the measured value, due to the amount adhering to the walls of the measuring tube and the collector. If the tipping bucket is in satisfactory adjustment, the record should agree with the measured value within 10 percent. In making this test, never use less than 0.50 inch of water. If the measured and recorded values are not in agreement within 10 percent, the bucket mechanism must be adjusted further.

16. Theodolite.—*a. Purpose.*—The theodolite is a specialized form of a surveying instrument, used to follow the movement of pilot balloons as they move upward through the atmosphere and are carried by the air flow at various levels. Reading of the elevation and azimuth angles at regular intervals enables the speed and direction of the winds at various levels to be measured.

b. Description.—(1) *General.*—The theodolite, in front and side views, is shown in figure 64① and ②. It is a telescope with a magnifying power of about 25 diameters. It is arranged so that the objective may be rotated completely about a vertical axis, and about a horizontal axis, through all angles from about −35°. It is equipped

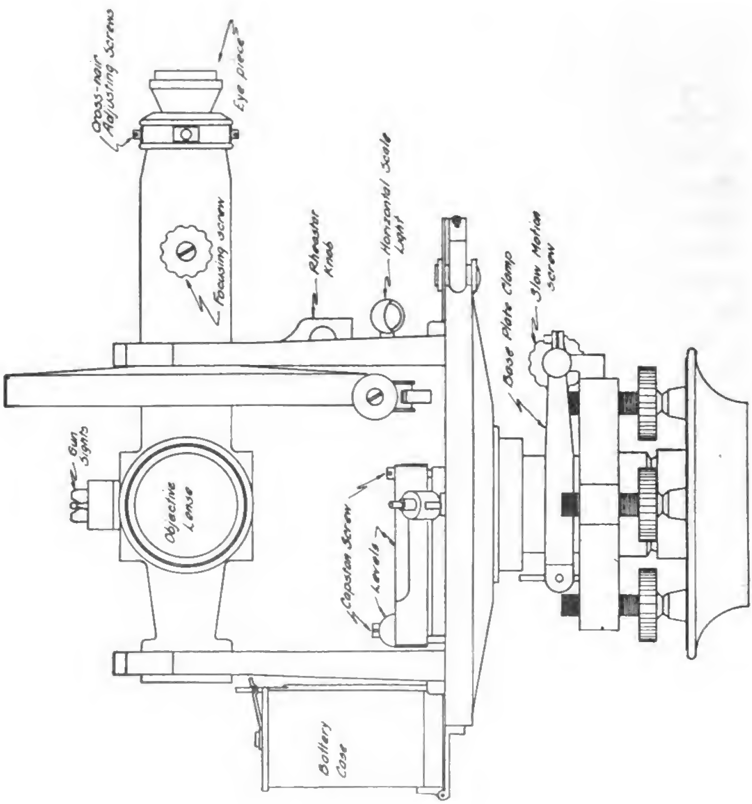
with a local battery circuit for illuminating the cross hairs and scales for night observations. Verniers are attached to the horizontal and vertical tangent screws. Other features are those common to all first-class surveying transits and are shown and labeled in figure 64.

(2) *Shifting tripod head.*—The theodolite is mounted on the tripod by means of a heavy circular brass flange threaded to fit over a correspondingly threaded flat stud on the tripod. The instrument itself rests on a flat portion of this flange, supported by four adjustable thumbscrews used for leveling. A circular hole in the center of the mounting head, or flange, permits the theodolite to be shifted in any direction about three-eighths inch from exact center. This adjustment is for making a final setting of the instrument by means of a plumb bob over a closely defined reference mark. Provision is made for suspending a plumb bob from a short brass chain attached to the center of the theodolite vertical shaft.

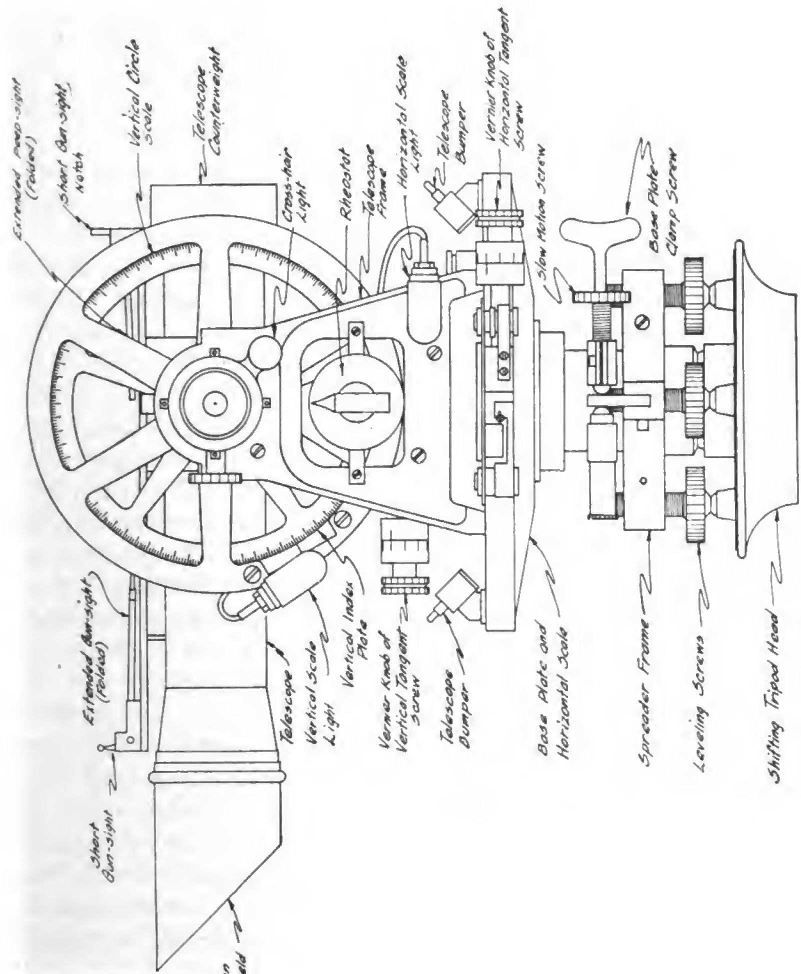
(3) *Leveling screws.*—Resting on the mounting head, through conical shaped feet, and supporting the theodolite through a spreader frame, are four thumbscrews used for leveling the instrument. They are evenly spaced 90° apart, and are so arranged that each pair of diametrically opposed screws, when simultaneously turned in opposite directions, tilt the instrument one way or the other.

(4) *Base-plate clamp.*—Directly above the spreader frame supporting the leveling screws, is a split collar which can be clamped tightly around the hub of the instrument base plate by tightening an extending screw. Off to one side of this split collar and integral with it, is a frame supporting another adjusting screw which acts against a projection on the spreader frame of the leveling screws over a very limited range. This screw, called the "slow motion" screw, has the effect of slowly rotating the base plate of the instrument when the base plate clamp is tight. This slow motion screw is useful in making minor adjustments in the orientation of the instrument about its vertical axis, without disturbing the azimuth setting on the horizontal scale.

(5) *Base plate.*—The horizontal circle, which is graduated in degrees, is an integral part of the theodolite base plate. This part is a brass disk, flat on one side and slightly conical on the other, with gear teeth cut around the entire circumference. A substantial hub extends from the conical under surface down through the base-plate clamp. The hub of this base plate is bored out to accommodate a vertical shaft which supports the telescope frame which rides over the base plate. It can be seen that if the zero of the horizontal scale on the base plate is set to a certain known direction, the direction in which the telescope


Cross-hair Adjusting Screws
Eye piece
Focusing screw
Rheostat Knob
Horizontal Scale Light
Base Plate Clamp
Slow Motion screw
Gun Sights
Objective Lense
Capstan Screw
Levels
Battery Case

① Front view.



③ Side view.
FIGURE 64.—Theodolite ML-47.

is turned can be determined in degrees with reference to this known direction.

(6) *Telescope frame.*—The telescope frame accommodates a pair of supports, or bearings, in which the horizontal axis of the telescope rotates. This frame also supports a tangent screw operating against the gear teeth of the base plate, a vertical circle graduated in degrees with its tangent screw, a battery case, two levels which are set at 90° to each other, and the telescope itself. Three small electric light bulbs are mounted on the telescope frame. One is to illuminate the cross hairs, and the other two illuminate the horizontal and vertical scales. A small off-on switch and a rheostat for controlling the intensity of the lights complete the equipment mounted on the telescope frame.

(7) *Levels.*—The two levels mentioned in (6) above are used to adjust the telescope frame to a true horizontal position. This is necessary to insure accuracy of the calculated data obtained from the use of the theodolite. As mentioned before, these levels are mounted on the flat portion of the telescope frame at 90° to each other. This arrangement facilitates the process of leveling the instrument. There is a screw adjustment at one end of each of these levels which permits a small amount of vertical motion of one end of each level. It can be seen that if the levels are not parallel to the theodolite base plate, no amount of adjustment by use of the leveling thumbscrews will be effective in making the instrument level in all positions. Therefore, an important theodolite adjustment is to make the levels parallel to the base plate. This adjustment, however, needs to be checked only periodically and should be made only if necessary.

(8) *Verniers.*—The horizontal and vertical tangent screws are so designed that one turn of the screw causes a motion of 1° on the corresponding scale. The knob of each tangent screw is provided with graduations which divide its circumference into 10 equal parts. One division on the knob represents one-tenth of a turn and consequently one-tenth of a degree. The vernier knobs are adjustable so that when the degree marks on the main scale coincide with the reference marker, and the scale on the knob is not at zero, the knob can be loosened from the tangent screw shaft and set to zero. Both tangent screws are mounted on a swivel at the end opposite the vernier knob, permitting the screws to be engaged or disengaged from the gear teeth on the circular scales. A snap catch holds the tangent screws in either the engaged or disengaged position.

(9) *Vertical scale.*—The vertical scale is a ring graduated in degrees mounted next to the telescope concentrically with its horizontal axis.

This ring, or scale, turns when the telescope is rotated about the horizontal axis. A reference marker is mounted on a fixed portion of the telescope frame, just above the vertical tangent screw which operates the vertical scale from the bottom. This reference marker is etched on a sector which is adjustable, and the marker may be moved by loosening a pair of clamping screws at the ends of the sector. When the telescope is horizontal, the vertical scale should read either 0° or 180°.

(10) *Telescope.*—The prismatic-type telescope used on this instrument permits the eyepiece to be at right angles to the objective lens. This is a convenient feature, as the observer can stand at a certain level and keep his eye to the eyepiece without stooping or stretching as the objective lens of the telescope is moved up or down. Also, the observer will be facing the vertical scale and can take a reading at a glance. There are two focal adjustments. The eyepiece may be turned until the cross hairs are sharply outlined. The objective lens is focused on the object being viewed by turning the focusing screw just behind the eyepiece. For rough sighting on an object, a set of short and extended gun sights are provided on top of the telescope barrel. The extended sights are used when the object being viewed is nearly overhead and cannot be picked up by using the short sights.

c. Care and adjustments.—(1) *General.*—The theodolite is an expensive and delicate instrument, and great care must be exercised in handling it and using it. The instrument must be kept free from dust at all times. It should be dusted with a soft cloth after each observation, and kept covered with a special canvas or cloth hood when not in use.

(2) *Objective lens.*—The objective lens must be protected by the sun shield during conduct of each observation. Following the observation, the lens should be cleaned with a piece of soft chamois skin, and the brass protective cap slipped over the lens.

(3) *Adjusting levels.*—If the levels on the telescope frame become out of adjustment, as evidenced by inability to make the instrument show level in all positions, it is evident that the levels are not parallel to the base plate. In order to adjust the levels and compensate for this discrepancy, the instrument should be leveled using one level only. With the base-plate clamp tight, aline one level with a pair of diagonally opposite leveling screws. Engage the horizontal tangent screw and adjust this one level until the bubble is central, using the pair of leveling screws mentioned. Note the reading on the horizontal scale and turn the theodolite through exactly 180°. Note the position

of the bubble in the level being considered, after this is done. If the bubble is still central, no adjustment of the level need be made. If the bubble is not central, however, one-half the amount of deviation from the central position of the bubble should be taken up by turning the small capstan screw at one end of the level. A small steel pin for this purpose should be included in the assortment of parts in the theodolite box. After one-half the deviation has been taken up with the capstan screw, the other half should be taken up by using the leveling screws. Starting from this position, the process should be repeated as from the beginning, and repeated as many times as necessary, until the bubble in this one level remains central for both positions 180° apart with only one setting of the leveling screws. After this one level has been adjusted the same procedure should be followed for the other level. When both levels have been properly adjusted, the instrument may be leveled, and when the theodolite is turned in any direction the bubbles in both levels should remain central.

(4) *Adjusting vertical scale.*—Although the whole vertical circle is graduated in degrees, only one quadrant, from 0° to 90°, is useful in measuring the elevation, or vertical angle, that a pilot balloon makes with the horizontal from the observation point. It is important that when the telescope is level or parallel to a horizontal plane, the vertical scale reading is zero. If this is true, it can be assumed that when the scale reads 90° the telescope is turned in a true vertical direction. In checking the vertical scale for a true zero, level the theodolite and set the vertical scale on zero. In this position, rotate the instrument about its vertical axis and pick up some convenient reference point. Otherwise, mark some point on a wall for a reference point. The telescope should then be turned over until the vertical scale reads exactly 180°, and the instrument should be swung around so that the objective lens again faces the selected reference point. If this reference point now falls on the cross hairs, the telescope is level and needs no adjustment. If, however, the original reference point is off the cross hairs, the tangent screw should be turned until the point is again on the cross hairs, and the difference in reading, or the amount turned, should be noted. The tangent screws should then be turned back one-half this difference, the index plate on the vertical scale should be loosened and moved until the index marker is exactly on the 180° graduation. The whole process from the beginning should then be repeated and when finally a chosen reference point appears at the cross hairs in both the 0° and 180° positions of the telescope, the zero adjustment of the vertical scale is correct. Finally, the vernier on the vertical tangent

screw may be adjusted to zero by loosening the screw holding the index knob and turning the knob to read zero when the index mark on the vertical scale is coincident with the zero mark on the vertical circle.

(5) *Adjusting verniers.*—As explained in the last portion of the above paragraph, either the horizontal or vertical vernier knob may be adjusted to read zero on a whole degree setting of the corresponding major scale, by loosening the screw holding the vernier knob to the tangent-screw shaft and setting the vernier knob to read zero when a whole degree graduation coincides with the reference marker.

(6) *Adjusting horizontal axis.*—If the horizontal axis of the telescope is truly horizontal, it will be possible to sight the cross hairs at the top of a long string suspending a plumb bob, and to follow the string down its full length with the cross hairs without changing the setting of the horizontal scale. It is obvious that if the horizontal axis is not truly horizontal, it will be impossible to follow the plumb line down with the cross hairs of the telescope. This would mean that one of the bearing supports on the telescope frame is too high or too low. There is an adjustment provided on the bearing support just behind the battery case for raising or lowering the horizontal axis a small distance. This adjustment is accomplished by turning a capstan screw at the bottom of the axis bearing. A locking nut is located just below the capstan nut and must be loosened before an adjustment is made. The most practical method of alining the horizontal axis to the horizontal, or making it perpendicular to the vertical axis, is as follows: After the theodolite is leveled, a reference point high on a wall is selected and brought to the cross hairs in the telescope. The horizontal tangent screw is engaged and the telescope is swung down to a low point on the wall where another reference point is selected and marked. The telescope is turned over, the instrument is turned through 180°, the upper reference point is sighted again on the cross hairs, and the telescope is turned down to pick up the lower reference point. If this lower reference point again comes into view at the intersection of the cross hairs, the horizontal axis is level and properly adjusted. If this is not the case, however, one-half the discrepancy must be taken up by adjusting the capstan screw at the end of the horizontal axis. The whole process is then repeated as many times as necessary to bring two reference points into line when viewed through the telescope in both its inverted and upright positions. The four adjustments listed under (3), (4), (5) above, and (6) should be made when the theodolite is first received at the station and every 6 months thereafter, if necessary.

(7) *Carrying theodolite.*—Special care must be exercised in the simple operation of carrying the theodolite, due to the ease with which it may be seriously damaged. When this instrument is being carried from the station office to the point from which the upper-air observation is to be conducted, it should invariably be carried along the side of the body, securely held under one arm, with the theodolite proper in front where it can be observed and protected from injury. The tripod may well be extending to the rear, not under direct observation at all times, because it is a sturdy, inexpensive part and not easily damaged. Only when the instrument is to be carried over long distances, and in the open, should it be carried on one's shoulder, with the theodolite proper to the rear.

17. Plotting board ML-55.—*a. Purpose.*—The plotting board ML-55 is used for plotting the horizontal projection of the path of the pilot balloon, as the latter is observed through the theodolite. This horizontal projection is normally plotted to the scale of 1 inch equaling 500 yards. From this projection, using a suitable protractor and speed scale, the direction and speed of the horizontal airflow at various altitudes can readily be computed.

b. Description.—(1) This board is shown in figure 65. It consists basically of an ordinary drafting board, with dimensions of 50 by 40 inches. A small brass stud is fitted into the center of the board so that the stud projects upward from the board surface about five-sixteenths inch. A special linen covering is fitted tightly over the board surface and held securely by thin wooden strips which are screwed into the edges of the board. This linen covering is printed with a large circular protractor, graduated in whole degrees. It also has one centering east-and-west line and numerous north-south lines, the latter being arranged about 1 inch apart. The lower left-hand portion of the board is printed as a grid, to be used in the graphical method of computing horizontal distances, employing the known altitude of the balloon and the elevation angle.

(2) The special brass scale ML-63, which is used with plotting board ML-55, is shown in figure 66①. This scale is graduated for normal use in plotting the horizontal projection to the scale of 1 inch equalling 500 yards, although it may be used for projections of any integral or fractional multiple of this scale.

(3) The speed-and-direction scale ML-137 is shown in figure 66②. The protractor portion of this scale is semicircular and is printed with a double scale graduated to intervals of 36 points to the circle. By orienting the protractor properly with respect to the north-south lines of the plotting board, the wind direction in degrees, for any

altitude, may be read directly from the horizontal projection. Speed scales, for the usual scales to which the projection is plotted, are printed along the edges of the protractor. Wind speeds, in miles per hour, are read directly from the horizontal projection, using this scale.

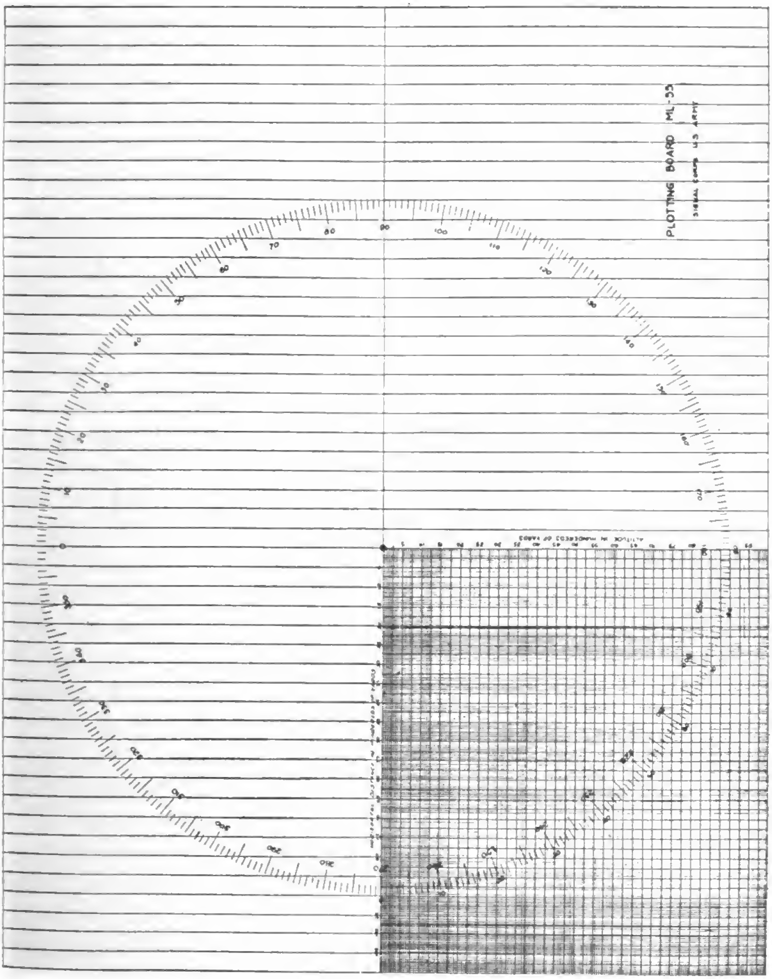
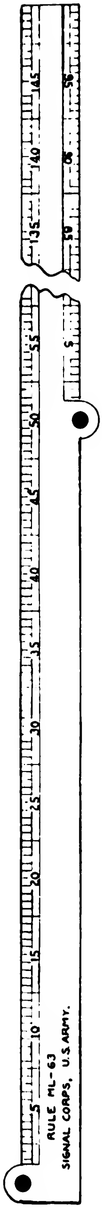
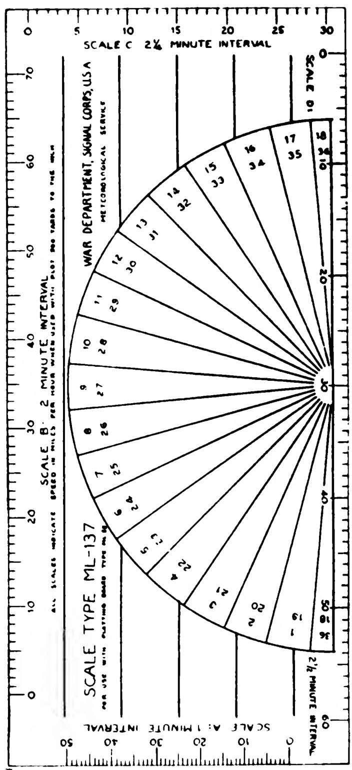


FIGURE 65.—Plotting board ML-55.

c. *Care.*—After long usage, the plotting board ML-55 may be renewed simply by removing the old cover and installing a new one. However, one cover, if properly treated and used, may be continued in use for 2 or 3 years without requiring replacement. Covers for



① Brass scale ML-63.



② Speed scale ML-137.

FIGURE 66.

this plotting board are requisitioned as expendable supplies. One extra cover should be kept on hand at each station at all times.

(1) As a first step in renewing the covering of the plotting board ML-55, the board proper should be prepared by removing the four wooden strips about the edge of the board and then removing the old cover. The board should then be cleaned of bits of dried paste remaining from the old cover, and the wooden surface made smooth by rubbing lightly with fine sandpaper or emery cloth. Next, lightly and evenly dampen the board with water, using a sponge or cloth. Now cut out a small hole in the center of the new covering. Place this covering face down on a table and moisten the unprinted side lightly and evenly with water, then cover it with a very thin coating of library paste. Place the cover down over the board, carefully fitting the center hole over the brass stud and orienting the cover so that the north-south lines are parallel to east and west edges of the board.

(2) Smooth the cover out with the palms of the hands, eliminating as many blisters as possible as they tend to form between the cover and the board. Do not stretch the cover too tightly in one direction at a time, or the center hole will be torn and the stud will no longer be in the center of the protractor. Bend the edges of the cover over the edges of the board and fasten with carpet tacks. To secure a neat folding at the corners, a small narrow strip must be cut from the cover at each corner. After the edges have been tacked down, screw on the wooden strips along the edge of the board. Usually, by this time, the cover will have a considerable number of blisters showing, but nothing further should be done at this time. Place the board, with its new cover, on a table, and let it dry for about 24 hours. Do not rest the board on edge during this drying period, or all surfaces will not dry evenly.

(3) At the end of the drying period, the cover will be found to have stretched smoothly and practically no blisters remain. Next, brush on a thin coat of clear lacquer. This should dry in about 1 hour. As soon as one coat of lacquer has dried, brush on another. Make certain that this work is done in a dust free room. Continue placing lacquer on the cover until at least 10 coats have been applied. The board is now completely ready for service and, with proper care, should remain in good condition for a long time.

(4) Never use anything but a pen and ink in plotting on board ML-55. The pen to be used must have a well rounded point. If too sharp a point is used, ink will be introduced below some of the

lacquer and that part of the board will remain discolored until the lacquer is removed and fresh coats are applied. If an ordinary pen point is used, and the plotter is careful not to prick the lacquered surface, the projections can be plotted without trouble. After the wind direction and speed values have been determined, the projection should be erased by using a soft, damp cloth. Hundreds of projections can be plotted on a given cover in this manner without there being any visible evidence of its use.

18. Robinson 3-cup anemometer ML-80.—*a. Purpose.*—The Robinson anemometer is designed for use in conjunction with either the quadruple or double register to produce a continuous and automatic record of wind movement, and to register a value of wind speed in miles per hour at any time.

b. Description.—(1) *General.*—The 3-cup anemometer consists of a tubular frame suitable for mounting on a standard wind instrument support, a cup wheel consisting of three hemispherical cups mounted on radial spokes, and a system of gearing which registers the action of wind movement on the rotatable cups. Provision is made both for recording the total wind movement over a given period of time, and for registering the wind speed over short intervals of time.

(2) *Spindle shaft.*—The cup wheel is mounted on a spindle shaft which carries the rotating motion of the cups through the tubular frame to gears in the dial case. A plain bronze bearing at the top of the frame and a step bearing at the bottom provide support for the spindle shaft. The transfer of rotary motion from the spindle to the gear system is accomplished through a single-thread worm cut integral with the spindle shaft at its lower end. This worm engages a gear inside the dial case which is known as the "vertical" or "one-sixtieth mile" gear. This is shown best in figure 68.

(3) *Vertical or one-sixtieth mile gear.*—The vertical gear, driven by the spindle, rotates on a horizontal axis together with another worm fastened to the same shaft. This second worm drives a small pinion gear which, in turn, drives the dial gears. This process completes the transfer of motion from the rotating cups to the registering dials. Considering wind as a stream of fluid substance, the anemometer cups and the gear ratio between the vertical gear and spindle worm are so designed that the movement of one-tenth mile of wind by the anemometer causes a complete revolution of the vertical gear. There are six evenly spaced projecting pins around the outer circumference of the vertical gear. Three of these can be observed in figure 68. As the gear rotates, the small projections on the vertical gear passing

a rounded projection on a spring contact arm cause this arm to be displaced, thus closing the path of an electrical circuit. The electrical contacts thus operated are called the one-sixtieth mile contacts, and they are connected to the frame of the instrument and to a terminal

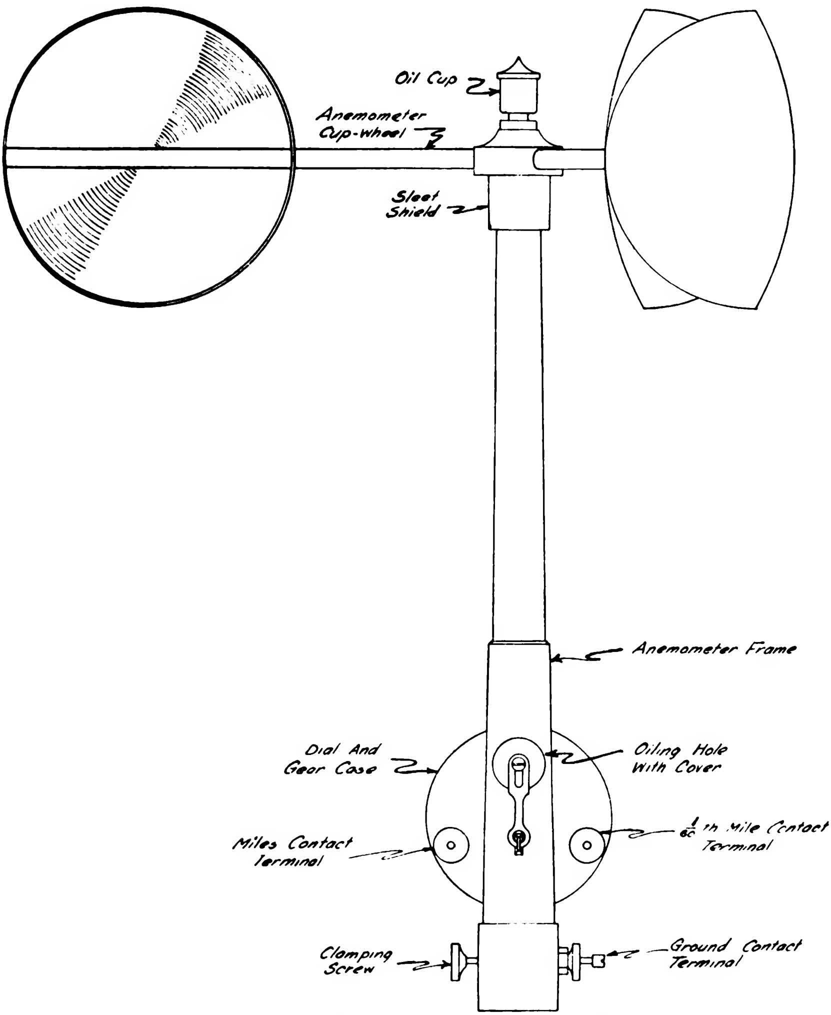


FIGURE 67.—Robinson 3-cup anemometer, rear view.

on the right side of the gear case, as viewed from the back. (See fig. 67.) It can be seen that the vertical gear rotates one-sixth of a revolution between intervals when these electrical contacts are closed. If

these one-sixtieth mile contacts are connected in series with a battery and a buzzer, the number of contacts occurring during a given period of time may be counted and the wind speed for that time may be deduced. Since a full revolution of the vertical gear represents one-tenth mile of wind, one contact will be made for each one-sixtieth mile of wind passing the anemometer. Thus by counting the number of contacts (buzzes) made in one minute, we have a measure of the air movement in miles per hour. Indicated wind speeds, as obtained from the 3-cup anemometer, are subject to certain discrepancies at the lowest speeds and at the higher speeds. A table of corrections covering the average range of wind speeds is shown below.

Speed in mph	*Correction in whole mph*
0– 16	+1
17– 26	0
27– 35	−1
36– 44	−2
45– 52	−3
53– 61	−4
62– 70	−5
71– 79	−6
80– 87	−7
88– 96	−8
97–105	−9

(4) *Anemometer dials.*—(*a*) As explained in (3) above, the anemometer dials are driven by the rotating cups through a system of worms and gears and finally by a pinion gear which rotates on a stud shaft which is perpendicular to the back of the gear case. This pinion gear is held on its shaft by a small nut with an elongated side, bearing an index mark to indicate the position of the upper dial in its rotation around its center. The upper and lower dials both mesh with the pinion gear and rotate about a common axis. They are separated by a thin washer to prevent excessive friction between them. The ratios included in the gearing-up to the dials are such that the upper dial makes one complete revolution with respect to the index nut for every 10 miles of wind passing the anemometer cups. There are 10 main divisions on the upper dial, each representing 1 mile of wind. These unit divisions are again subdivided into 10 parts, each representing one-tenth mile. There are, therefore, 100 divisions on the upper dial, and since there are 100 gear teeth around the circumference of this dial, the passage of each tooth past the index nut represents one-

tenth mile. The lower dial, however, has only 99 teeth, and since both dials are meshed with the same driving pinion, it can be seen that each time the upper dial makes a complete revolution, the lower dial makes one complete revolution plus one tooth. The lower dial is graduated with markings for each 10 miles. Thus, for each movement of 10 miles of wind the two dials will be displaced, with respect to each other, by one marking of the lower dial. An index mark on the upper

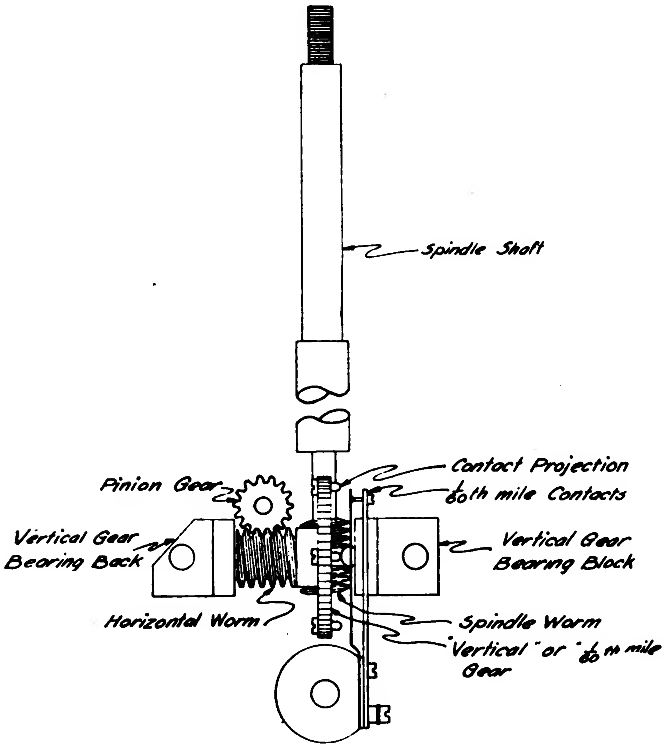
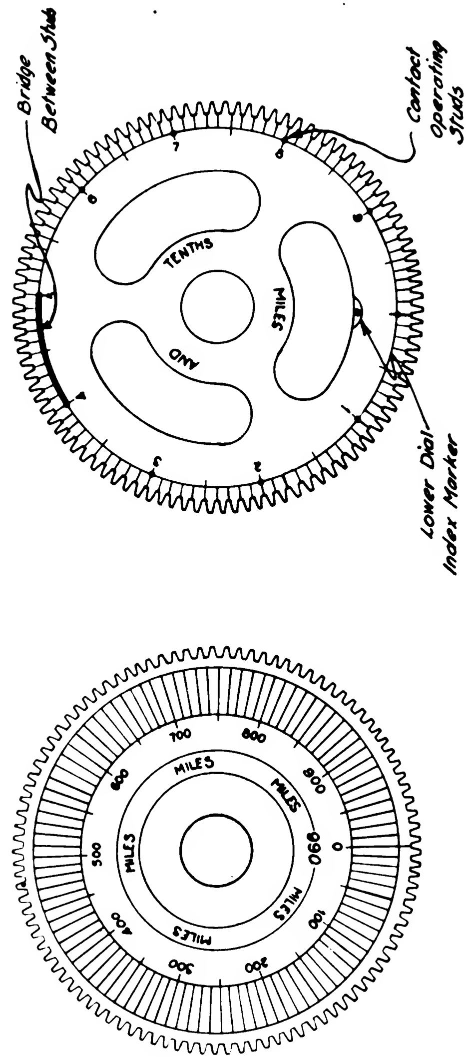


FIGURE 68.—Anemometer gears.

dial is used to register the whole tens of miles shown on the lower dial. Since there are 99 teeth on the lower dial, its limit of registry is 990 miles of wind. Therefore, the anemometer dials register hundreds and tens of miles of wind on the lower dial, and units and tenths of miles on the upper dial. It is obvious that after the anemometer dials have reached their limit of registry, they will start all over again from zero, and unless some provision is made to record the total number of miles of wind passing the anemometer, the dial readings for each

group of 990 miles would be lost. The quadruple or double register, as described later, provides for recording of the full movement of wind.

(*b*) The upper dial is provided with 10 short pins, arranged near the



② Upper dial.

① Lower dial.

FIGURE 69.—Anemometer dials.

periphery of the dial and extending upward about one-quarter inch from the upper face of the dial. These pins are separated from each other by a distance which, in the movement of the dial, is equivalent to 1 mile of wind. The top dial, with contact spring assembly, is

shown in figure 70. A thin brass spring, which serves to make the contact which completes the electric circuit at the end of each mile of wind, is shown in this drawing. The fixed (left) end of this spring is mounted on a stud which extends upward from the back metal base of the anemometer. This fixed end is thus grounded for one side of the electric circuit. The free (right) end of the spring has a small platinum electrode on its under surface. This end normally stands separated from a similar electrode on the pin which connects to the

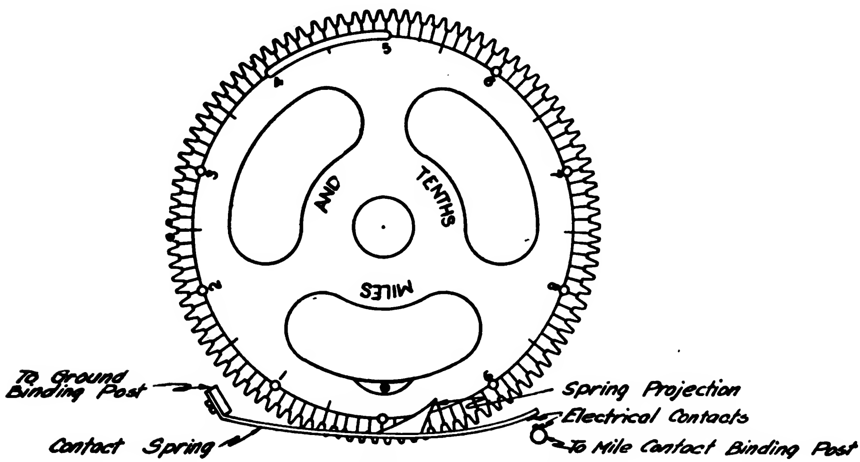


FIGURE 70.—Anemometer mile-contact spring.

mile-contact binding post. Along the length of the contact spring a somewhat triangular-shaped projection falls in the path of the dial pins as they rotate in a counterclockwise manner. As the rotating cups cause the dial to turn, the dial pins are successively moved on to this spring projection. As the dial turns farther, the pin forces the right end of the spring to make contact with the electrode leading to the mile-contact binding post. The circuit will remain closed at the electrodes until further movement of the dial carries the pin to the right of the spring projection. Then the spring is released, the circuit is broken at the electrodes and remains open until the next pin moves into position to force the spring to make contact. While the circuit is closed a current of electricity is permitted to flow through an electromagnet of the quadruple or double register, which causes an associated pen to record the mile of wind.

(c) Pins Nos. 4 and 5 are connected by a bar so that when pin No. 4 has moved into position to depress the contact spring, the electric

circuit will remain closed throughout the interval between No. 4 and No. 5, and will not be broken until pin No. 5 moves to the right of the projection. Thus, during each series of recordings of 10 miles of wind, there will be one extra long contact made and this will be recorded as a distinctly different marking. This is used to facilitate obtaining the record of the total wind movement over a period of time, as will be explained in the section on Weather Forms.

c. Installation.—A separate wind-instrument support is usually provided for mounting anemometers and registering wind vanes. There is a standard 12-foot support made of 1¼-inch pipe intended primarily for mounting on the roof of a building. This support is equipped with an offset arm near its top, for mounting the anemometer, a bearing cap at the top for a wind vane, foot rungs, and guy rods with turnbuckles for providing lateral bracing. There is another standard wind-instrument support 18 feet high, intended for surface mounting or on a roof. This support is similar to the 12-foot support, with the exception that 2-inch pipe is used and a box near the base is provided for mounting a wind-direction contactor unit. The anemometer is mounted on a short stud on the extended arm of the support. Three wires are necessary to carry the electrical circuits to the station, and these should be run through pipes of the frame, where possible, to protect them from weather. Care should be exercised in the placement of an anemometer to locate it in the path of free-moving air. Locations near the sides of buildings, or between buildings or other obstructions, should be avoided.

d. Reading anemometer.—There are certain specified times when the anemometer should be read and the readings recorded. Readings should be taken at noon, local time, on the first day of every month and on every Monday. The number of hundreds and tens of miles is read from the lower dial, as indicated by the position of the lower dial with respect to the index marker on the upper dial. The units and fractions of a mile are read from the upper dial, with respect to the index nut on the pinion-gear shaft. However, fractions of a mile are not recorded, and the upper dial is read to the last whole mile which has passed the index marker. Since the dials turn counterclockwise, the unit mile is obtained by reading the dial pin number first to the left of the index marker.

e. Care.—(1) The 3-cup anemometer should be thoroughly serviced and overhauled regularly once a month. After the anemometer has been disconnected from its wires and dismounted from its support, it should be completely dismantled and all the parts except the frame,

rotating cups, spindle shaft, and dial cover should be dropped into a bath of gasoline as each part is removed. The oil cup (fig. 71) which screws to the top of the spindle shaft holding the cup wheel tight is removed first. The cup wheel may then be lifted off. Next, using the special anemometer wrench, loosen the bronze bearing at the top of the anemometer frame. The spindle shaft may then be lifted out. The bottom step bearing, shown on figure 72, is then

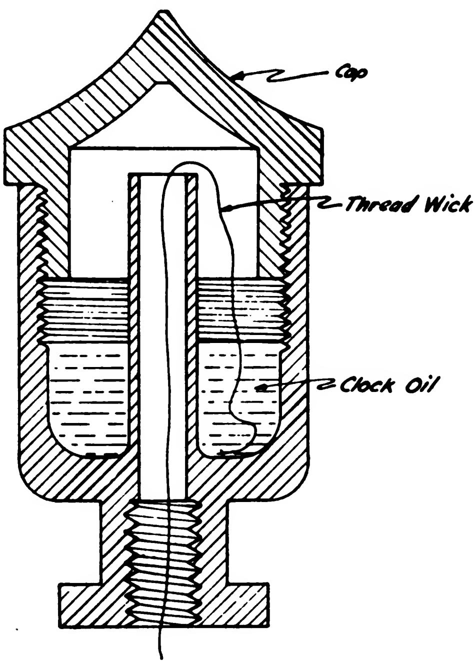


FIGURE 71.—Anemometer oil cup.

unscrewed, through the bottom of the instrument frame, by means of a long screw driver.

(2) Two screws on the back of the dial case may next be removed to loosen the dial cover exposing the anemometer dials and gears. A flat screw at the center of the dials is removed to take off the upper and lower dials. Next, the index nut on the pinion shaft is unscrewed and the pinion gear may be slipped off. The two bearing blocks, shown on figure 68, are next removed, and this permits lifting out the vertical gear. The parts remaining on the anemometer frame are the two electrical contacts, and it is not necessary, nor is it recommended, that they be removed. The only attention these contacts require is

that the points of contact be cleaned carefully with fine emery cloth.

(3) The oil cup should be opened by unscrewing the cap. The old clock oil and wick should be removed. The well should be rinsed out with gasoline and then cleaned with a soft cloth. A few drops of new oil should be placed in the well, a new wicking installed, and the cap replaced.

(4) The bottom bearing, figure 72, should be unscrewed, using a long-bladed sturdy screw driver. The top of this bearing should be

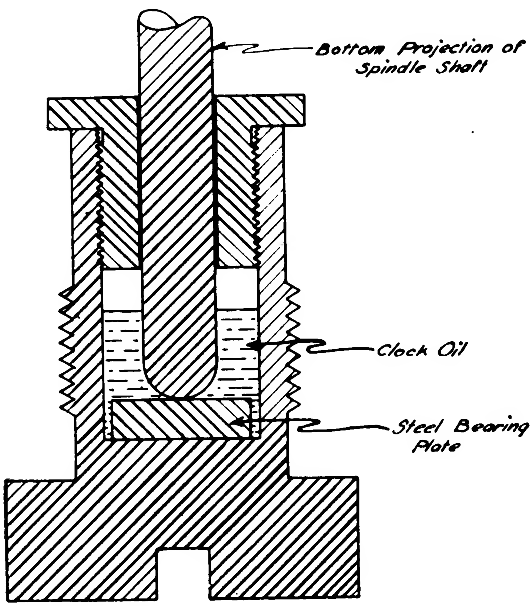


FIGURE 72.—Bottom bearing of the anemometer.

unscrewed, and the bottom steel bearing plate removed and examined for wear. After long use, this bearing plate will develop a depressed worn surface. When this depression has developed to the size of a pin head, the bearing must be turned over to expose a better bearing surface. If both sides are worn, the bearing must be replaced. Each station should maintain a small supply of these bearings. While the bearing is removed, the well should be rinsed with gasoline and a new supply of oil introduced. In dropping the steel bearing into place, care must be observed to see that it rests flat on the bottom of the well. Unless shaken into proper position, this bearing will often tend to stick in a sidewise position, thus giving a very defective bearing for the lower end of the spindle.

(5) All of the remaining parts, when taken from the gasoline bath, should be dried clean and free of dirt and oil, using a clean dry cloth. They should be replaced in position in an order reverse to that by which they were disassembled. The vertical gear and its bearing blocks should be replaced first, and so on. All parts that rotate or slide on mating parts should be oiled with clock oil.

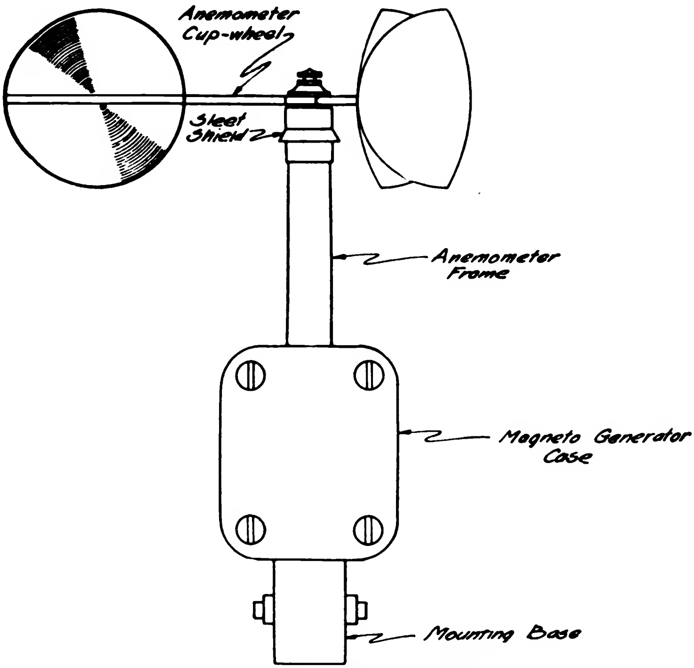


FIGURE 73.—Magneto-generator anemometer.

(6) After the gear assembly has been reinstalled and the glass covering attached, the bottom bearing should be screwed into position firmly and snugly. The spindle shaft should be installed next. While the spindle shaft is being installed, the frame should be held in one hand, with the observer looking toward the back of the anemometer. The oil-hole window should be open. With the other hand, lower the shaft through the frame and, by observing the top of the bottom bearing through the oil window, make certain that the bottom end of the spindle is properly entered into the bottom-bearing housing. Now close the window hole and finish the assembly by installing, in order, the top bronze bearing, the cup assembly, and the oil cup.

(7) Each time that the anemometer dial is read, between the dates of major cleaning, the top and bottom bearings should be oiled with

a good grade of clock oil. This can be done by merely unscrewing the cap of the oil cup and opening the oil window in the rear of the dial case.

19. Magneto-generator anemometer.—*a. Purpose.*—The mag-

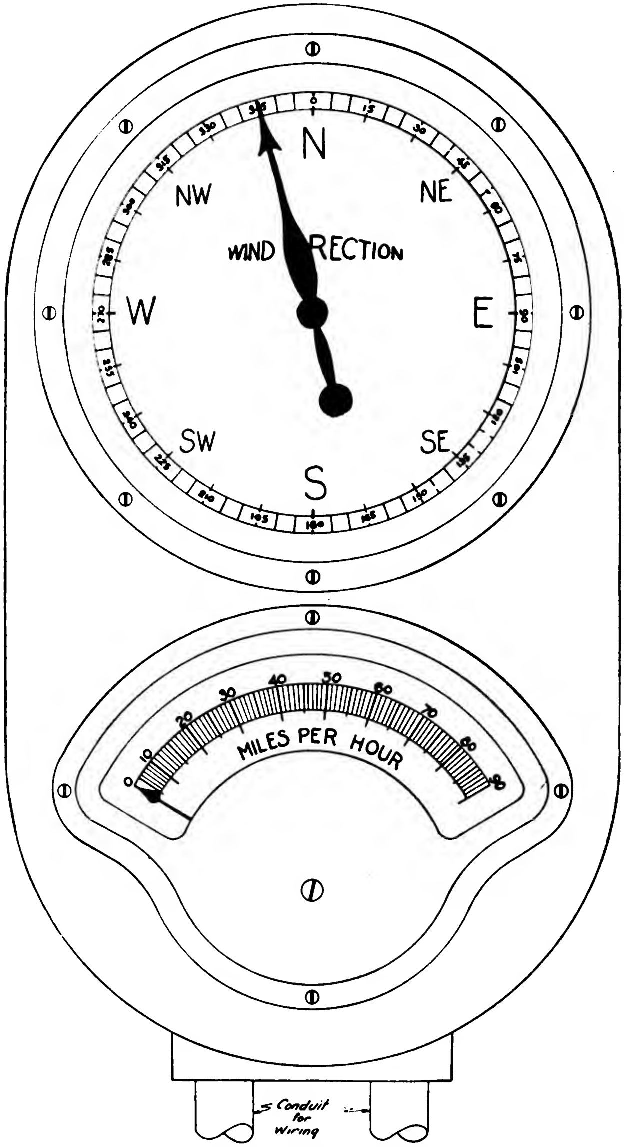


FIGURE 74.—Bulkhead indicator.

neto-generator anemometer is designed to indicate instantaneous wind speeds. Due to its continuous indications, it has the added feature of indicating rapid changes in wind speed, or gustiness.

b. Description.—This instrument consists of a 3-cup wheel similar to that used on the Robinson 3-cup anemometer, and a sturdy aluminum frame which houses a self-excited magneto-generator unit. The cup wheel is fastened to a spindle shaft which is connected to the rotor of the magneto-generator. A cylindrical hood, an integral part of the cup wheel, drops down over the anemometer frame and offers protection against freezing rain or sleet, so that the cups will be free to rotate under all weather conditions. The generator is a standard manufactured item which is sealed within the instrument case and needs no attention over long periods of time. Figure 73 shows the magneto-generator anemometer.

c. Installation.—This instrument is usually mounted on a standard wind-instrument support, such as described in paragraph 18*c*.

d. Use.—The magneto-generator anemometer is used in conjunction with an indicating device known as the "bulkhead indicator." This indicator consists of two scales, one for indicating wind speed in miles per hour, and the other for indicating wind directions in degrees. (See fig. 74.) The wind-speed scale is on a portion of the indicator which is nothing more than a voltmeter calibrated in miles per hour. As the anemometer cups are turned by the wind, a certain voltage is built up in the magneto-generator. The value of this voltage rises in proportion to an increase in wind speed and thus, since the voltmeter scale is graduated in miles per hour, a direct or instantaneous wind speed reading may be obtained from the bulkhead indicator. This bulkhead indicator should be mounted inside the station where convenient, and the two necessary wires may be led out to the anemometer through suitable conduit.

e. Care.—Since the magneto-generator is in a sealed case, no attempt should be made to dismantle it. If trouble develops, it should be sent back to the manufacturer for service. The ball bearing at the top of the anemometer spindle shaft should be oiled every 2 or 3 months, and the zero setting of the bulkhead indicator needle should be checked in about the same interval of time. If, when the cup wheel of the anemometer is at rest, the needle on the indicator is not on zero, it should be set to zero, using the adjusting screw on the face of the bulkhead indicator.

20. Wind vane.—*a. Purpose.*—Wind vanes are used to indicate or register the direction from which the wind is blowing at any time.

b. Description.—(1) *General.*—The wind vane generally used consists of a plate of metal forming a tail, attached to one side of a vertical axis free to rotate in response to changes in wind direction. The windward part of the vane is formed of an arrow-tipped rod which points into the wind and also serves to counterweight the tail. The spindle is a steel rod about 2 feet long for the plain wind vane and for the contacting type used with the light indicator, the lower end turning in a pivot bearing. The bearing proper for the contacting wind vane assembly, and that for a vane used without contacts, are alike. Wind vanes are used in connection with such indicating devices as the nine-light wind-direction and speed indicator, the selsyn-type wind-direction indicator, and with the cam collar in conjunction with the quadruple register. These devices are described in detail in succeeding paragraphs.

(2) *Wind vane bearings.*—These assemblies consist of a piece of half-inch pipe, with keyway bushing to form the top bearing, and a pivot support to form the lower bearing. The wind-vane axis is equipped with a special cam and a weather-protection housing rigidly attached. On the contactor-type vane a set of insulated contact springs is mounted on the collar that fits over the half-inch pipe.

c. Installation.—To set up the device for use, first erect the half-inch pipe bearing in the desired location. Then fill the bearing about half full of light automobile oil. Next, slip the contact spring assembly over the pipe, if contacts are used, and temporarily clamp it, springs upward, with the lower edge of the brass collar between the two rings that will be found marked on the pipe. The axis should now be inserted, being careful to rotate it slowly so as to "feel" the key in the axis through the keyway in the top bearing. This key arrangement permits withdrawal in one position only. Next put on the vane with due regard to provision made for insuring its position relative to its axis, generally a pin extending into a hole in the brass housing of the axis.

d. Care.—The only care required for a wind vane is to check it occasionally to see that it moves freely in its bearings and is properly oiled.

21. Cam collar.—*a. Purpose.*—The cam collar is a mechanism used to convert wind directions as indicated by a wind vane into electrical impulses which will register on an automatic recording instrument.

b. Description.—The mechanism of the cam collar is a simple arrangement of circular cams so placed around the outside circumference

of a cylindrical brass collar that, as the collar rotates progressively, the succeeding combinations of cams will produce a series of eight different and distinct combinations. (See fig. 75.) There are four identical cams placed side by side on the collar of the mechanism, each located differently with respect to the others around the circumference. The circular length of each cam is three-eighths of a full circle, or 135° of arc. The arrangement of these cams is such that the middle one-third of each cam is entirely free from overlap by any other cam. This accounts for four distinct conditions where each of the four contact rollers will be actuated alone and separately as the collar rotates. In addition, the cams are so arranged that the first one-third and the last one-third of each cam overlap with the opposite portions of an adjacent cam. Thus, there are four more

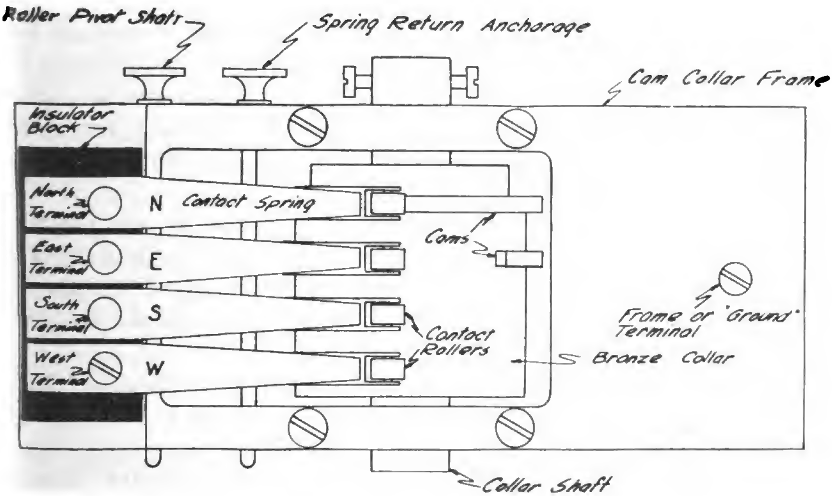


FIGURE 75.—Cam collar.

combinations created when the last one-third and the first one-third of a pair of cams actuate a pair of contact rollers. It is obvious that there are eight possible combinations for actuating the contact rollers which, in turn, create a closed path for an electrical circuit through the north, east, south, or west terminals and the frame, or "ground" terminal. In other words, if, for example, the north and east contact points were closed simultaneously, it would be possible to operate two separate magnetic devices through the electrical paths provided by the closing of these two contactors. Further, a certain amount of rotation of the collar in one direction would cause the east contact to open, leaving the north contact closed. Rotation in the opposite

direction would cause the north contact to open, leaving the east contact closed. It can be seen that, as the cam collar rotates clockwise from north to east, etc., a progressive series of eight directions will be registered by the closing of corresponding combinations of electrical circuits. The electrical circuits thus actuated are connected to the quadruple or double register which produces a continuous and automatic record of wind directions over a period of time.

c. Installation.—The cam collar is installed in a cast iron box provided for the purpose in the standard 18-foot wind instrument support mentioned in paragraph 18*c*. This box is provided with gaskets under its covers to make it weather-tight and a pair of mounting screws which fit into slots in the ends of the cam-collar frame. The cam collar is mounted in its box so that the axis of the collar is vertical, permitting the wind vane shaft, which is usually three-eighths inch, round steel rod, to pass through it. The wind vane is pointed and held in some known direction, and the cam collar is turned to a point where the cams actuate the corresponding direction contacts. Then the set screws on the collar are tightened against the wind-vane shaft. The cam collar is now ready to be wired to the quadruple or double register inside the station.

d. Care.—The only care the cam collar requires is that the bearings in which the collar rotates be oiled every 2 or 3 months and that the surface of the cams and rollers be kept clean so that good contact will be maintained between the frame of the mechanism and the direction contacts and terminals.

22. Selsyn-type wind-direction indicator.—*a. Purpose.*—This instrument is designed to indicate instantaneous wind directions on a dial scale remotely located from a wind vane.

b. Description.—The selsyn-type wind-direction indicator consists of two identical motor units. One, commonly called the "transmitter," is mounted in a case and frame exactly like that of the magneto-generator anemometer; and the other, known as the "receiver," is mounted in the case of the bulkhead indicator. The transmitter unit has a spindle shaft extending 6 inches above the top of the frame to accommodate the hub of a standard wind vane. The receiver unit is connected to a dial pointer through a pair of right-angle gears in the bulkhead-indicator case. (See figs. 74 and 76.) The word "selsyn" is a contraction for self-synchronous, the operation of the instrument being based upon the principle of mutual reaction between two self-synchronous motors. Both the transmitter and receiver units are built like ordinary electric motors having stator windings

and rotor windings. Figure 77 shows a schematic drawing of the rotor and stator units of the two synchronous motors of the direction transmitter and the receiver. There are three separate stator windings in each unit, star connected, and the corresponding leads of the transmitter and receiver are connected together. The rotor windings of both units are connected in parallel and excited with 110 volts a-c. The rotor of the transmitter unit is connected to the wind-vane shaft, and the rotor of the receiver is connected to a pointer on

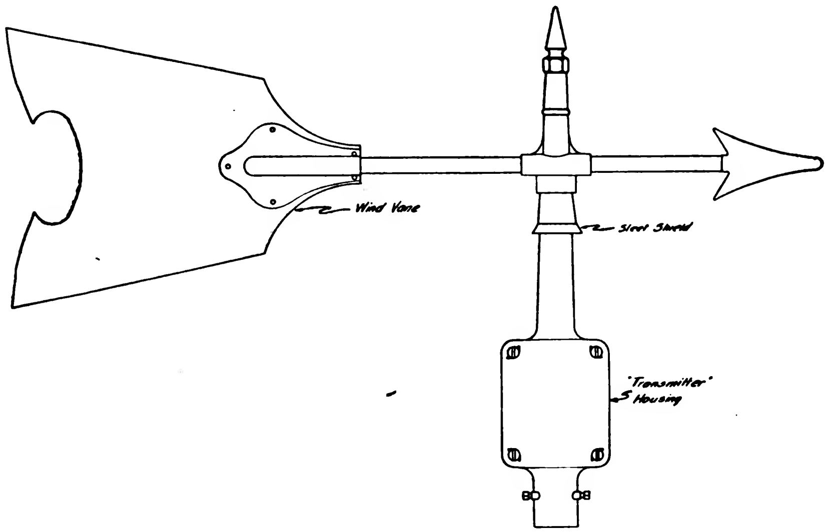


FIGURE 76.—Selsyn-type wind-direction indicator.

the wind-direction dial of the bulkhead indicator. As the wind vane moves, the energized transmitter rotor moves accordingly and induces a magnetic field in the stator winding which is characteristic of the position of the rotor for any instant. As the position of the rotor changes, the distribution of the induced magnetic field in the stator windings changes accordingly. Since the stators of the transmitter and receiver are connected together, the magnetic-field conditions produced in the transmitter are reproduced in the receiver and react on the rotor in the receiver in such a way as to cause it to duplicate the motions of the transmitter rotor. In this way, wind directions indicated at any instant by the wind vane outside are reproduced by the needle connected to the receiver rotor inside at the bulkhead indicator.

c. *Installation.*—The transmitter portion of this instrument is

mounted on a standard wind-instrument support, such as described in paragraph 18*c*. The bulkhead indicator should be mounted on a wall at some convenient location in the station. Provision must be

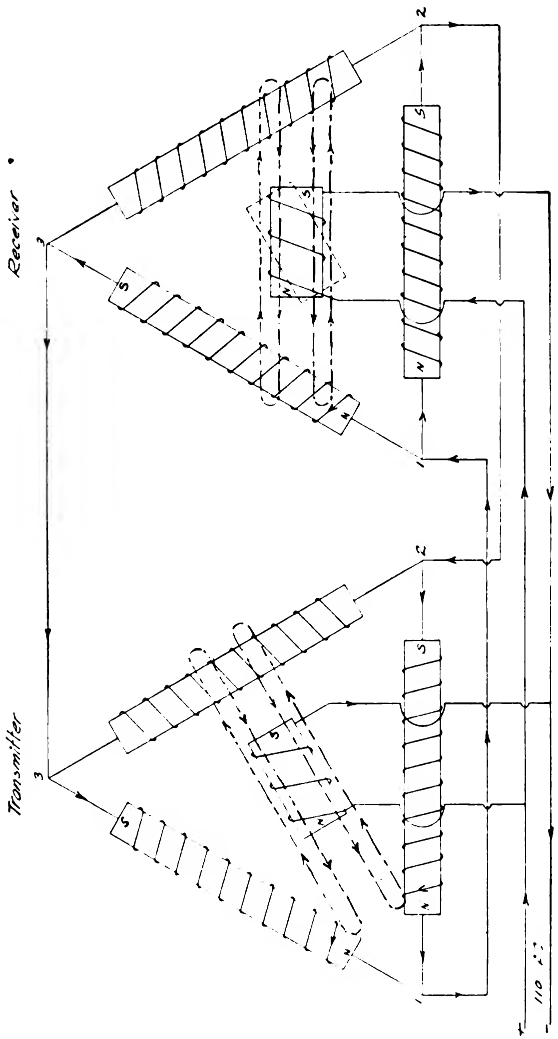


FIGURE 77.—Synchronous-motor wind-direction transmitter and receiver.

made for carrying five wires from the transmitter to the bulkhead indicator through suitable conduit. A connection must also be made from the rotors to a source of 110 volts, a-c, preferably at the bulkhead indicator. To orient the indicating needle on the bulkhead indicator, the wind vane outside may be held to some known direction.

The cover of the dial on the bulkhead indicator should be removed, the needle screw loosened, and the needle set in the direction corresponding to the wind-vane direction.

d. Use.—True wind directions at any instant are transmitted from a wind vane to the dial of the bulkhead indicator where these directions may be read to the nearest 5 degrees. Since this instrument is conveniently located in a station, where it can be observed almost constantly, it is most valuable in noting wind shifts.

e. Care.—Since both the transmitter and receiver of this instrument are sealed units of standard manufacture, it is not recommended that they be dismantled for servicing or any other purpose. In case of failure, they should be returned to the manufacturer for service. The top bearing of the transmitter spindle should be oiled every 2 or 3 months. At these times the spindle shaft should be cleaned of any rust or corrosion, and oiled to prevent sticking of the wind vane on this shaft. The right-angle gears connecting the receiver rotor to the indicator needle should also be oiled at these intervals by removing the dial case and reaching under the dial with an oil can.

23. Nine-light wind-direction and velocity indicator.—*a. Purpose.*—The light indicator is a device intended to indicate instantaneous wind directions and wind speeds on a dial scale remotely located from a wind vane and anemometer.

b. Description.—(1) *General.*—The light indicator consists of two essential units. One is a wind-vane assembly having eight cam-operated, normally open switches, and the other is a round dial having eight lights spaced evenly around its circumference. (See figs. 78 and 79.)

(2) *Dial unit.*—The eight lights around the circumference of the dial represent eight directions of the wind scale. It is possible that two lights may be lighted at one time, due to the cam arrangement operating the two switches at the wind vane. In such a case, the wind direction, between the eight directions marked on the dial, is indicated. Thus, the light indicator will indicate 16 directions of the wind scale. A green light in the center of the dial face is used to indicate wind speed in miles per hour. It is connected to the one-sixtieth mile contact of a Robinson 3-cup anemometer and may be used selectively. A buzzer is also mounted under the dial face, which may be used instead of the center light by throwing the lower left-hand switch mounted on the dial case to the "on" position. If it is desired to use the green light, turn the middle switch on the dial case to the "on" position. The lower right-hand switch is used to turn the wind direction lights on or

off. There are two variable controls for changing the intensity of the various lights on the dial: the one on the right is for the direction lights, and the one on the left is for the velocity light. A small step-

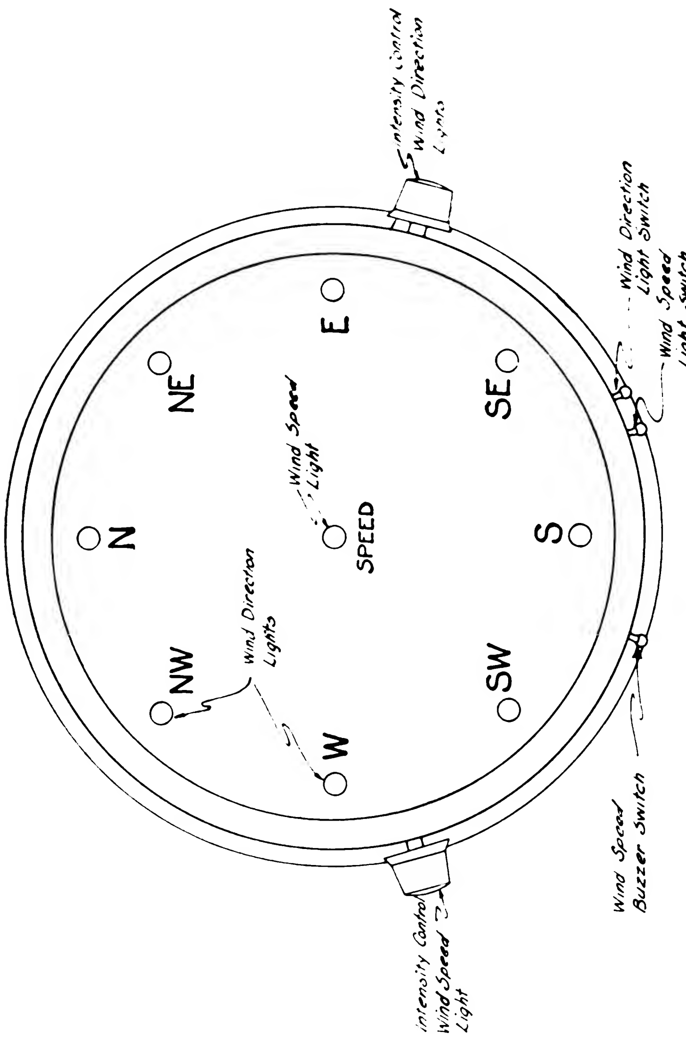


FIGURE 78.—Light indicator dial.

down transformer mounted within the dial case supplies 10 volts, a-c, to all the bulbs and the buzzer.

(3) *Wind-vane switch assembly.*—Eight normally-open spring contactors, evenly spaced and mounted on a circular head near the base

of a wind-vane bearing, serve as the operating elements for the lights on the indicator dial. A cam fastened to the wind-vane shaft is so designed that it will close either a single switch or any pair of adjacent switches. This assembly is shown in figure 80. A protective cylinder

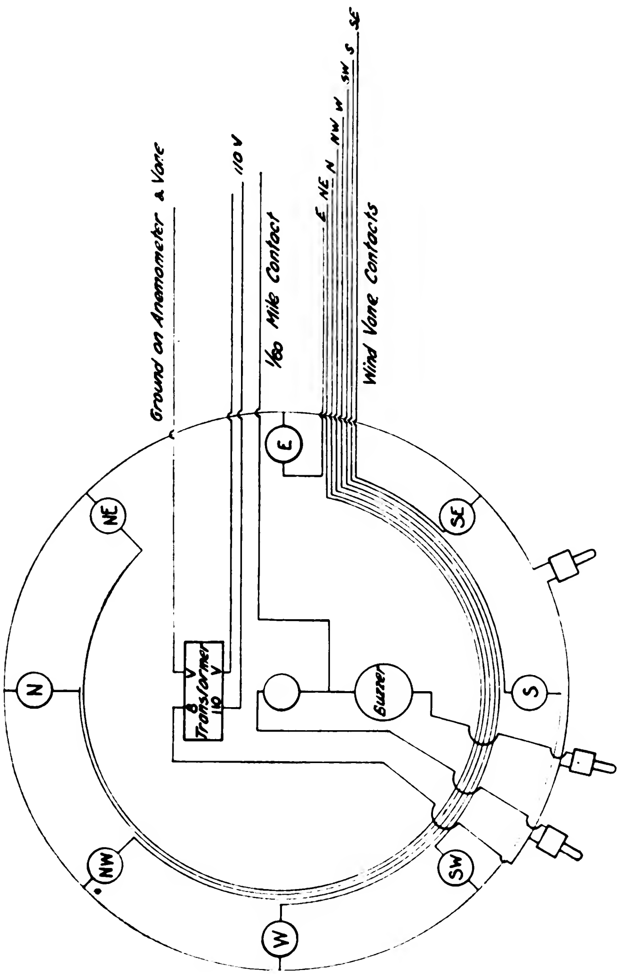


FIGURE 79.—Light indicator switch assembly.

is provided to cover the switches as a protection against sleet. It can be seen that there are eight separate electrical circuits which can be operated singly or in pairs to register 16 combinations on the dial lights of the light indicator. The common circuit or return for all these contactors is through the frame of the switch assembly. Therefore, it is necessary to lead into the station, where the light indicator

is located, nine wires for indicating wind directions and two more from the 3-cup anemometer to indicate wind speeds.

c. Installation.—The wind-vane switch assembly may be mounted on a standard wind-instrument support, as described in paragraph 18*c*. The light-indicator dial should be mounted conveniently for observation on a wall in the station. It will be necessary to connect

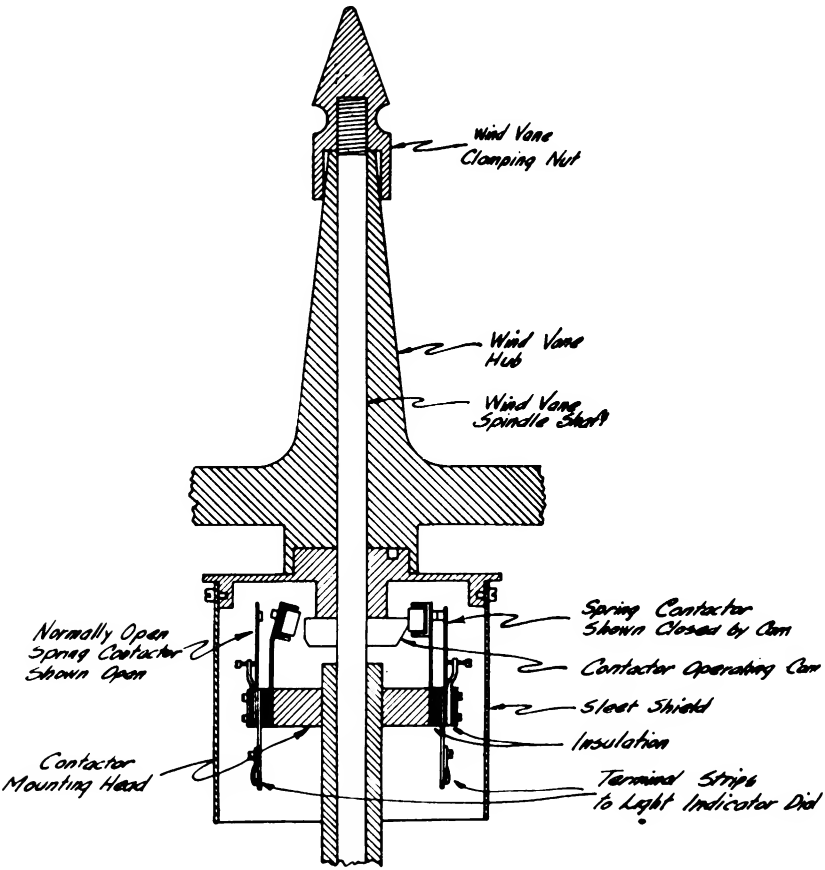


FIGURE 80. Wind-vane switch assembly.

a source of 110-volt a-c current to the primary of the transformer inside the dial case, for operating the lights and the buzzer.

d. Care.—No service is required on the dial assembly of the light indicator beyond replacing unserviceable bulbs. In order to reach the bulbs, it is necessary only to snap off the dial cover. The wind-vane shaft and bearing should be oiled occasionally, and the contact points

inspected for wear and pitting. If the contact points are dirty or pitted, they should be carefully cleaned with fine emery cloth.

24. Quadruple register.—*a. Purpose.*—The quadruple register is designed to produce a continuous and automatic record of rainfall,

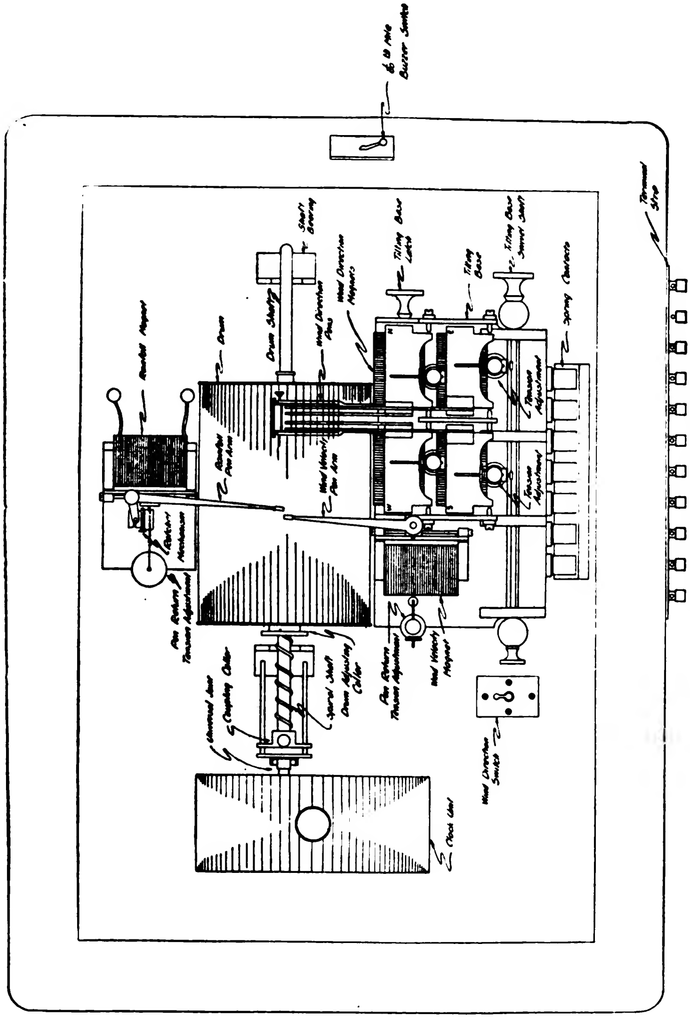


FIGURE 81.—Quadruple register.

wind speed, wind directions, and duration of sunshine over a period of time.

b. Description.—(1) *General.*—The major parts of a quadruple register consist of a clock to drive a drum containing a record sheet,

and six electromagnets, arranged so that when they are energized they will actuate various pens in accordance with impulses received from the rainfall-, sunshine-, and wind-measuring instruments. The use of the sunshine recorder has been discontinued in the Army Air Forces Weather Service; and since the same electromagnet and pen are used to record sunshine and rainfall, we shall hereafter omit any reference to the sunshine pen and refer to it only as the rainfall pen. (See fig. 81.)

(2) *Clock unit.*—The clock unit used on the quadruple register is of sturdy construction, provided with two springs for driving the register drum, through a universal joint and a sliding coupler. A rotating contact arm is so arranged that the wind direction magnets will be energized at intervals 1 minute apart. The cam is rotated

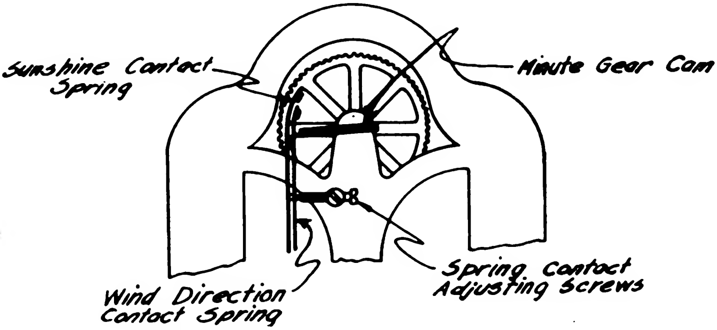


FIGURE 82.—Quadruple-register clock contacts.

by the minute gear of the clock. The wind-direction and sunshine contact springs are so placed that their contact electrodes fall within the path of this cam. Thus, at the end of each minute, the electric circuit is closed through the cam collar and the proper one- or two-direction electromagnets mounted on the tilting base of the register. The sunshine spring contact is usually adjusted so that no contact is made with the cam, inasmuch as we no longer record the duration of sunshine. The adjusting screws permit maintaining a proper amount of contact between the cam and the spring electrode.

(3) *Drum.*—The drum on which the quadruple-register record sheet is placed is 4¾ inches in diameter and 6 inches long, and rests on a pair of brass bearing frames. The right end of the drum shaft, viewed from the front, is plain round, and the left end is provided with a spiral thread. This spiral thread fits into a corresponding spiral groove cut into the left bearing, and serves to carry the drum to the right as it is revolved by the clock. In this way it is possible to create

a spiral trace on the record sheet which is longer than would be possible with a single turn of the drum. The rotating speed of the clock driving shaft is such that four complete revolutions of the drum are made in 24 hours. Integral with the drum shaft are a pair of bushings on which the drum itself fits with a light friction fit. This arrangement permits rotation of the drum to the proper starting point on the chart with respect to the pens.

(4) *Rainfall pen.*—The rainfall pen produces a trace from which may be obtained the number of times the tipping bucket of the tipping-bucket rain gage has tipped during a given period. The trace is in the form of a line of interrupted direction. Due to the pen being guided by a pin resting in a helical groove, the direction of the trace will be interrupted in one direction over a period of time required for five movements of the armature of the electromagnet. Following this, the direction will be interrupted five times in the opposite sense. The resultant trace will be as shown in figure 83. When no current

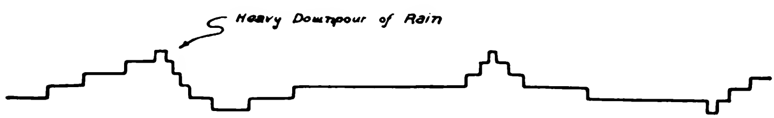


FIGURE 83.—Rainfall record trace.

is actuating the electromagnet, the pen is at rest on the record sheet, and the rotation of the drum traces a horizontal line. When the tipping bucket causes the rainfall magnet to be energized, the pen is carried up one notch as determined by a progressive ratchet mechanism. The frequency of the interruptions to the direction of the trace increases with an increased rate of rainfall.

(5) *Wind-speed pen.*—The miles contact of a 3-cup anemometer controls the electromagnet operating the speed pen. Each time a mile of wind passes the anemometer, the contact closes through the anemometer spring contact, permitting current to flow through the speed electromagnet, thereby moving the armature and associated pen over to mark the beginning of a mile spur on the trace. (See fig. 84.) The pen will remain in this position as long as the contact remains closed in the anemometer. As soon as the pin passes over the projection on the anemometer contact spring, the spring is released, the contact is broken, the circuit is opened, and the armature with its associated pen moves to its normal position, completing the spur on the speed record. Another spur will be made whenever the wind movement brings a pin of the top dial of the anemometer onto and

over the projection of the anemometer contact spring. The long spur shown in figure 84 was made when the connecting bar between pins 4 and 5, as shown in figure 70, passed over the projection of the anemometer contact spring. This long spur is, in effect, two regular spurs joined. The speed pen and its electromagnet mechanism are mounted on a tilting base which can be lifted away from the drum to allow removal from its bearings.

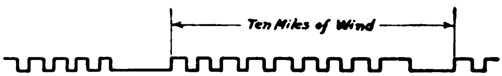


FIGURE 84.—Wind-speed record trace.

(6) *Wind-direction pens.*—(*a*) Four individual electromagnets are used to actuate the wind-direction pens. These electromagnets and their mechanisms are mounted on a tilting base which carries also the speed magnet and pen mentioned above. The selection of the direction magnet, or pair of direction magnets, to be energized is made at the cam-collar mechanism which is operated by a wind vane. The

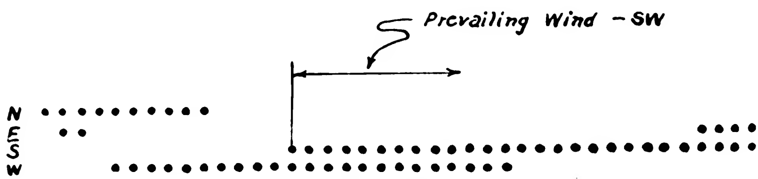


FIGURE 85. Wind-direction record.

actual completion or energizing of the circuit takes place every minute when the rotating clock cam momentarily closes the common lead from all four electromagnets through the direction contact spring of the clock. (See fig. 82.) In this way, wind direction is registered every minute on the record sheet by a single point or combination of two points made by the pen, or pens, being momentarily brought into contact with the chart. Each direction has a marked position on the chart and may easily be distinguished.

(*b*) Unlike the rainfall and wind-velocity pens, which are similar to the pens used on the thermograph, the wind-direction pens are blunt points having no capacity to hold ink. They brush against an inked-felt pad when they are actuated, and carry along only enough ink to make a mark when they strike the record sheet.

(*c*) In order to obtain an instantaneous wind-direction reading without waiting for the clock cam to make contact, a switch is pro-

vided just at the left of the tilting base, which will energize the wind direction pens instantly.

c. *Installation.*—The quadruple register should be placed conven-

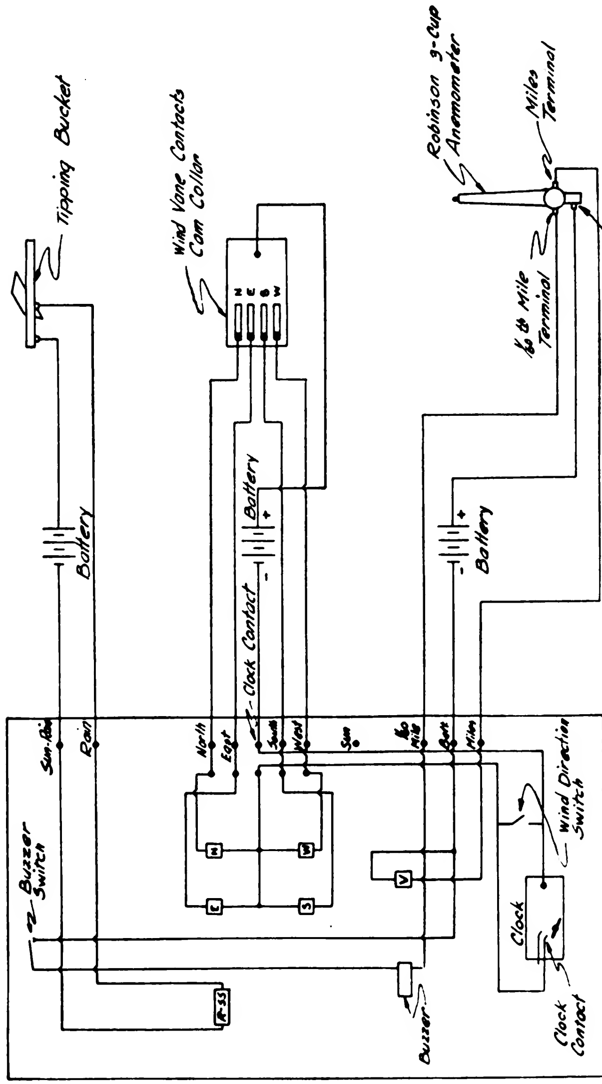


FIGURE 86. Wiring diagram, quadruple register.

iently in a weather station where the wiring from the anemometer, cam collar, and the tipping-bucket rain gage can easily be led in through suitable metal conduit. It should be wired in accordance

with the diagram shown on figure 86. Three sets of batteries are required which will produce about 6 volts of current for each of the three circuits.

d. Use.—(1) *Preparing the chart.*—Form No. 100 is the record sheet used on the quadruple-register drum. It contains space for a 24-hour record of rainfall, wind speed, and wind direction. As explained before, the various traces are for a 6-hour period on any one line as the lines are offset and form a spiral when the sheet is on the drum, the drum making four complete revolutions in 24 hours. The upper half of the chart is used for recording wind directions only. On the lower half, both rainfall and wind-speed traces are recorded. The information called for in the blank spaces on this form is self-explanatory and the required data should be entered as obtained from readings of the various instruments. Space is provided at the left end of each wind-speed trace for entering the total miles of wind for each 6-hour period. These entries should be made after the chart is finished and has been taken from the drum.

(2) *Changing the chart.*—After the new chart has been prepared, open the glass case of the quadruple register, lift off the rainfall-pen arm and swing it around 90°. Lift the wind-velocity pen arm about one-half inch and loosen the tilting base by pulling out the locking shaft. Raise the tilting base and loosen the set screw on the clock shaft coupling. Slip off the coupling from the drum shaft, and lift out the drum. Remove the spring bands. Remove the old chart and place it carefully between blotters to prevent smearing the ink of any part of the record. Place the new form on the drum, aligning the margin of the record-receiving area with a marking on the edge of the drum, so that no horizontal shifting of the drum will be necessary to have the pens fall into their proper positions with respect to the record sheet. Fit the bottom edge of the form snugly against the flange of the drum nearest the spiral-shaft end. Replace the spring bands. Place the drum in the extreme right position, facing the instrument side having the terminal strip. Slip the coupling on the drum shaft without tightening, and rotate the drum until it moves to its extreme left position. Tighten the coupling to the drum shaft. Lower the tilting base and lock it in place. Lower the wind-velocity pen to within one-eighth inch of the chart, and set the drum for time, making the last adjustment clockwise as viewed from the spiral-shaft end of the drum. This is to take out lost motion in the coupling and gearing of the clock. Swing the rainfall pen around and place it on the chart, and completely lower the velocity pen to the chart. If the record

sheet has been carefully adjusted to a previously prepared marking on the edge of the drum, the pens will fall into proper position when lowered to the sheet. Slight adjustment may be made by slipping the drum on its friction mounting.

e. Care.—(1) The batteries for the electrical circuits must be watched carefully to see that an ample supply of electric energy to operate the several electromagnets is available at all times. If wet cells or storage batteries are used, they should be inspected weekly. The best arrangement for a power supply to the quadruple register is to use the normal station lighting system, applying power to the register through a transformer to reduce the voltage and a rectifier to provide direct current voltages. When a transformer and rectifier are used, an auxiliary set of storage batteries should be available for emergency use.

(2) The wind-direction contact in the clock requires frequent attention. The electrodes should be cleaned with fine emery cloth once during each week. The length of the contact should be adjusted at the same time by use of the contact adjusting screw. If the contact is too long, the clock may be stopped, due to the pen arms making contact with the drum for too long a period of time. Sometimes the adjusting-screw threads become worn, so that the slight jarring of the pen arms hitting the drum each minute will permit the spring contact to move out of adjustment. An extra adjusting screw should be kept available.

(3) The felt pad, which carries the ink for the wind-direction pen arms, should be inked each time the record sheet is changed. A new pad should be installed about once a month. The tension adjustments for the armatures need little care, but they should be checked frequently.

25. Double register.—*a. Purpose.*—The double register serves to provide an automatic and continuous record of wind speed and wind direction.

b. Description.—(1) *General.*—The major parts of the double register are similar to those of the quadruple register with the exception that the arrangement is more compact and no tilting base is used to remove the pens from the drum. Figure 87 shows a plan view of the double register with all its component parts.

(2) *Clock unit.*—The double-register clock unit is similar to the quadruple-register clock unit with the exception of the drum-coupling mechanism. In this case an external gear, integral with a sliding couple, is mounted on the drum shaft in such a way that when the

drum bearings are released, the drum, shaft, and clock gear all lift out as a unit.

(3) *Drum.*—With the exception that the double-register drum is shorter than the quadruple-register drum, and the spiral driving shaft is on the right, facing the instrument, it is similar to the quadruple-register drum. The double-register record sheet also turns four times in 24 hours, producing a spiral trace when the chart is on the drum. Since there is no rainfall record made on this record sheet, the chart is about half as wide as the quadruple-register chart. Both the wind-speed and wind-direction traces fall in the same space provided on the chart. Figure 88 shows the double-register record sheet.

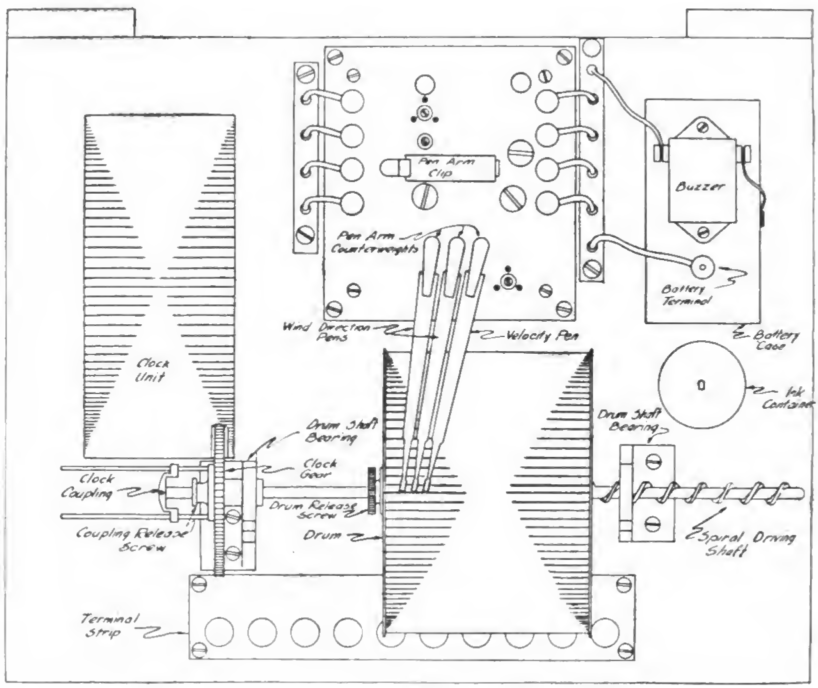


FIGURE 87.—Double register.

(4) *Wind-speed pen.*—Paragraph 24*b*(5) describes the operation of the quadruple-register speed pen. This explanation applies in the same way to the double-register speed pen which produces exactly the same form of speed trace.

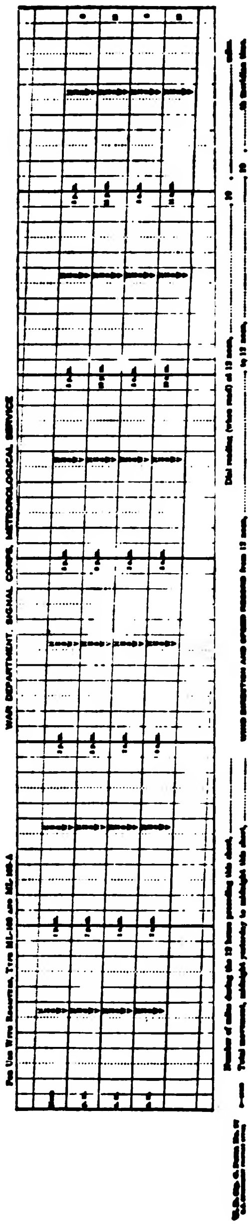
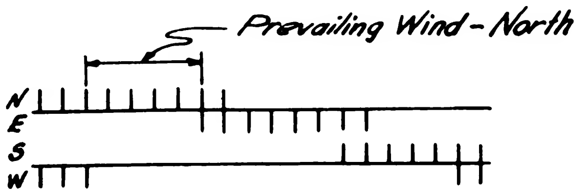
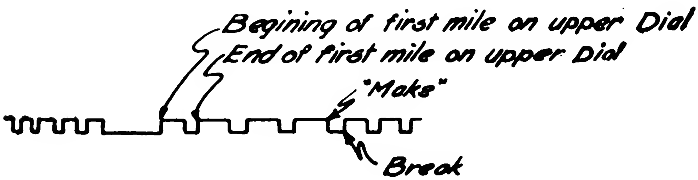


FIGURE 88.—Double-register record sheet.

(5) *Wind-direction pens.*—Here there is a major difference between the quadruple register and the double register. Two pens instead of four are used to record wind directions. Instead of a series of dots occuring every minute, short stub lines projecting from one side or the other of two parallel lines running along the length of the chart, indicate the direction of the wind being recorded. (See fig. 89.) Four electromagnets are still required to produce this trace, but only two pen arms are used in such a way that two cardinal directions are recorded on the sides of each neutral line which is drawn when the



① Wind direction.



② Wind speed.

FIGURE 89.—Sample traces from double register.

electromagnets are not energized. In the case of semicardinal directions where it is necessary for the pen to move first to one side of a neutral line and immediately to the other side, a double contact arrangement in the clock is provided so that as the cam, which revolves every minute, strikes the contact points, one point is closed and opened a second or so ahead of the other contact point. A study of the wiring diagram shown in figure 90 will assist in understanding the recording circuits.

c. Installation.—The same procedure as explained in paragraph 24*c* applies to the double register. Figure 90 should be used as a guide for wiring the instrument to the cam collar and 3-cup anemometer. Self-contained dry-cell batteries are used.

d. Use.—(1) *Preparing the chart.*—Form No. 97 is the record sheet used on the double-register drum. The information required in the blank spaces is self-explanatory. See figure 88, which shows the double-register record sheet.

(2) *Changing chart.*—After the new chart has been prepared, open the metal case of the double register, lift off the three pen arms and fold them back. Release the drum-shaft bearings and lift out the drum assembly. Remove the spring bands and take off the old chart.

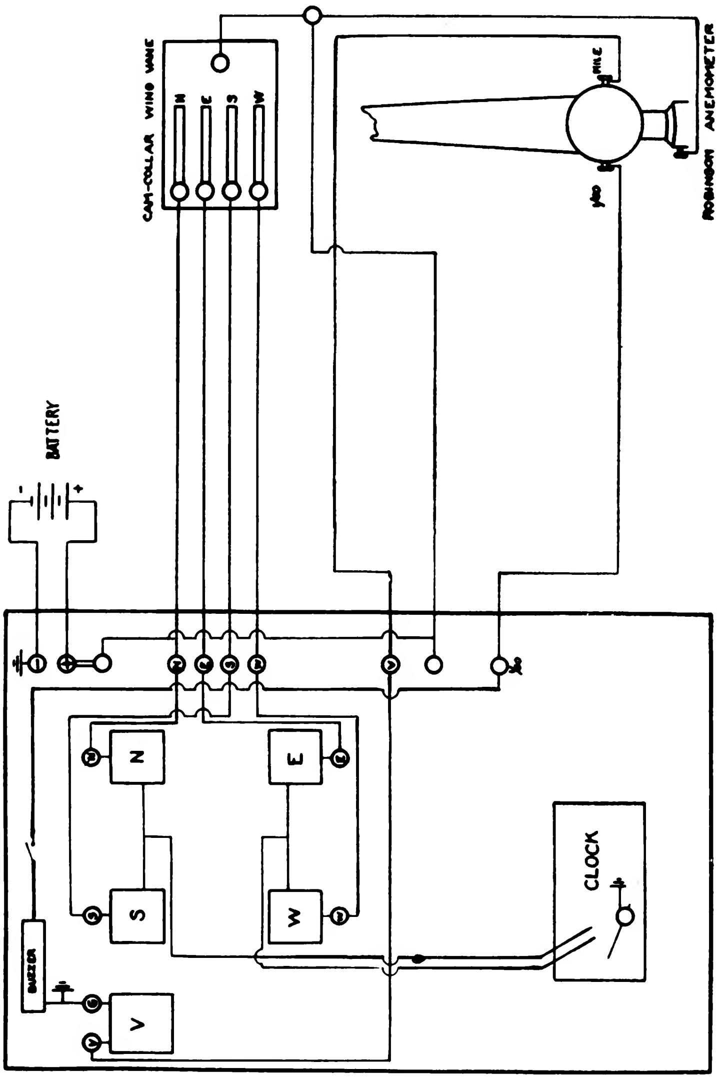


FIGURE 90.—Wiring diagram, double register.

This chart should be placed carefully between blotters to prevent smearing of the ink records. The new chart is placed on the drum with its bottom edge against the spiral-shaft end of the drum. Insert the

drum assembly in its bearings and lock the bearing caps in place. Rotate the drum to the extreme right, and with the drum-release screw loosened and the coupling-release screw loosened, turn the drum until the chart overlap is on top-center. Holding the drum with the right hand in this position, replace the three pens with the left hand and allow the pens to fall exactly on the overlap of the chart. Still holding the drum with the right hand, turn the drum shaft with the left hand until the three pens are within the space on the chart provided for the two traces, then tighten the coupling-release screw and the drum-release screw. The drum will now be rotated by the clock and drawn along its shaft, providing for a spiral trace of wind speed and direction.

(3) *Reading traces.*—*The wind-direction trace* will be a pair of parallel lines, from which short, lateral lines project about one-eighth inch. These lateral lines may be made singly, or in combinations of two, from either side of the two parallel lines. (See fig. 89.) The prevailing-wind direction for a period will be determined by the greatest number of any one type of single projections, or the greatest number of any particular combination of two projections. *The wind-speed trace* occupies the same space on the double-register record sheet as the wind-direction trace. The procedure for reading the speed trace on this instrument is exactly the same as on the quadruple register. A buzzer, connected to the one-sixtieth mile contact of the 3-cup anemometer, is mounted on the double register and may be used to measure instantaneous wind speed. It is controlled by a toggle switch mounted in the base of the instrument at the lower right-hand corner.

e. Care.—(1) The double register may be operated from an internal battery system which consists of two small dry cells, or it may be operated by an external battery system of either dry or wet cells. When either system is used with dry cells, careful check must be kept to insure that there is enough electric current to operate the electromagnets. When wet cells are used, they should be checked once a week.

(2) A weekly check of the clock contact springs should be made. If any dirt has collected on the electrodes, or they have been burned, clean them with a small piece of fine emery cloth. The duration of contact between the minute-wheel cam and the electrodes should be checked at this weekly inspection. Care should be taken to insure that friction between the contacts is not great enough to stop the movement of the clock. The clock should be cleaned and oiled once

each year by a competent clock repairer or jeweler. A small amount of clock oil should be placed in the drum-axle bearings once a week.

(3) Sometimes clock stoppage may be caused by too close a mesh between the cogwheel on the drum axle and the cogwheel of the clockwork with which it is engaged. The proper mesh may be obtained by turning of a setscrew located in the front of the clock base. Located on top of the armature box are six adjusting screws. An adjustment by use of these setscrews is seldom required. The three setscrews labeled "armature adjustment" move the armatures on movable plates, and it is thus possible to regulate the lateral movement of the respective pen arms. The three setscrews labeled "tension adjustment" regulate the tension on the pens, so that the pens will return to normal position after they have been pulled to one side by an electromagnet.

26. Ceiling light.—*a. Purpose.*—The ceiling light is a light projector used in determining the height of the base of clouds.

b. Description.—(1) *General.*—The ceiling-light projector consists of a metallic drum housing a set of parabolic reflectors, a powerful incandescent lamp, and a mechanical arrangement for focusing. This drum is mounted on trunnions which permit elevation of the light beam from the horizontal to the vertical. The trunnion arms are mounted on a casting, which serves as a transformer case and a base for a slip-fit mounting over a vertical stud consisting of 4-inch standard pipe.

(2) *Airplane-type lamp.*—The lamp theoretically best for use in a projector of this type is one in which the source of light is a brilliant point. Approaching this ideal is a lamp ordinarily used for airplane landing lights in which the luminous filament is concentrated in a very small space. This lamp is for use with low voltage, having a nominal rating of 12 volts, 420 watts, and 35 amperes. It has a mogul prefocus base and its average life is about 100 hours. Although other types of lamps are used in some of the older projectors operating on higher voltages, the airplane-type lamp is preferable because of its concentrated filament.

(3) *Reflectors.*—The primary reflector (see fig. 92) is a high-grade, back-silvered, 16-inch glass parabolic reflector. The auxiliary reflector is also of the same construction but smaller, and is designed to redirect the "spill light" and utilize it in the main beam.

(4) *Primary focusing assembly.*—The auxiliary reflector, the airplane-type lamp with its base, and a frame which provides support and adjustment for both the above items comprise a unit which may

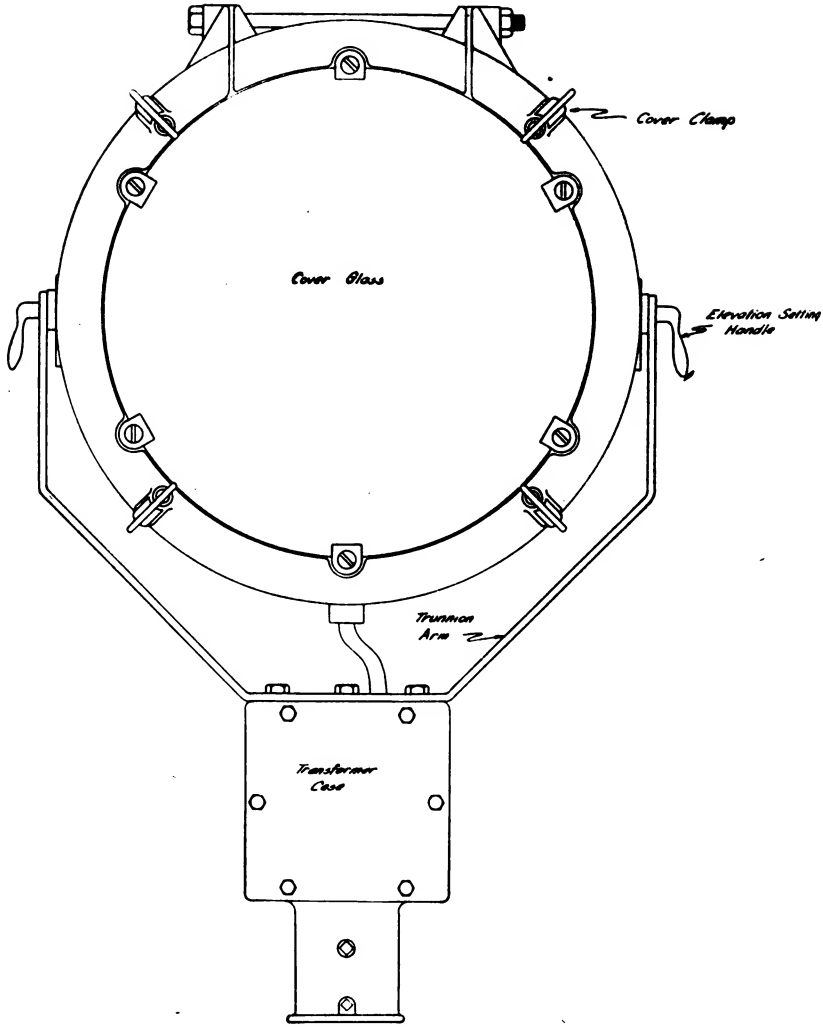


FIGURE 91.—Ceiling light—front view.

be termed the "primary focusing assembly." When this whole assembly is properly adjusted with respect to the primary reflector, a very concentrated and narrow beam of light is given off from the projector. The unit parts of this assembly, however, must be properly adjusted with respect to each other, and this is best done when the assembly is dismounted from the case. These adjustments will be described in detail in succeeding paragraphs.

(5) *Step-down transformer.*—The transformer provided for low-

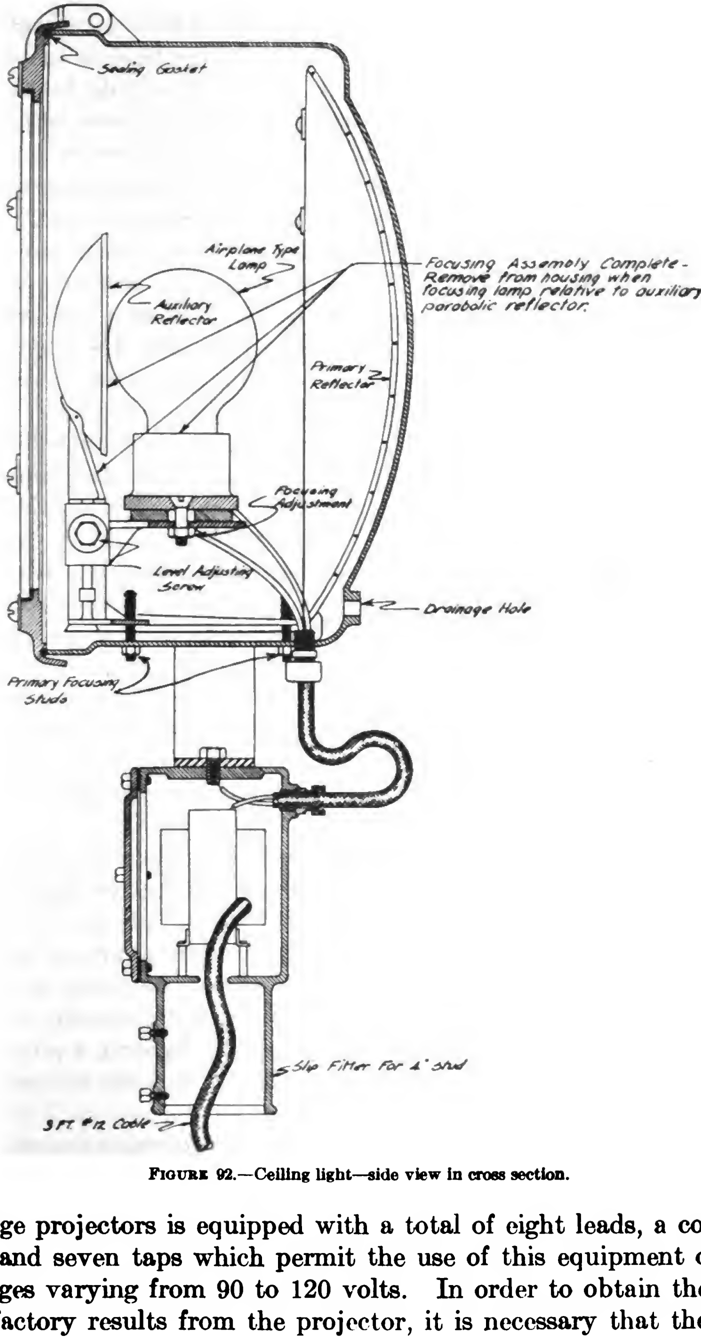


Figure 92.—Ceiling light—side view in cross section.

voltage projectors is equipped with a total of eight leads, a common lead and seven taps which permit the use of this equipment on line voltages varying from 90 to 120 volts. In order to obtain the most satisfactory results from the projector, it is necessary that the lamp

be checked under full load conditions to see that it is operating at its rated voltage. If the measured voltage at the lamp is too high or too low when it is operating, the line connection should be adjusted to the proper primary tap which will produce the correct rated operating voltage at the lamp terminals. This transformer is rigidly mounted in the cast case above the slip fitter, and provision is made to carry the power leads to its primary winding through the 4-inch pipe stud mounting, thus permitting all wiring to be totally inclosed.

c. Installation.—(1) *Location of projector.*—The low-voltage projector should be placed not less than 750 feet, and as a rule not more than 1,000 feet, measured horizontally, from the observing point. It is not necessary that the projector and the observing point be on the same level when a clinometer is used. A control switch for the projector should be located outdoors where the observer will be out of the glare of lights. The line of sight from the observation point to the projector should preferably be from south to north in order to avoid occasional inconvenience due to moonlight.

(2) *Mounting the projector.*—Projectors are provided with a slip fitter for mounting at the top of a 4-inch iron pipe. This device slips over the top of the pipe and is then clamped to it by set screws. A section of 4-inch pipe, 6 feet long, is set 3 feet into the ground. A flat stone should be placed under the end of the pipe. The ground should be thoroughly tamped about the lower end of the pipe to make sure of rigidity. A collar of concrete about 4 inches thick and extending about 8 inches above the surface should be provided to hold the pipe firmly.

(3) *Leveling the projector drum.*—A graduated quadrant is furnished on the side of the housing between the drum and the trunnion arm to permit indications of elevation from 0° to 90°. Two machined surfaces are provided on this quadrant, located 90° apart, so that by means of a spirit level it is possible to adjust the beam in such a manner that it may be checked horizontally and vertically. Verticality of the projector beam may be checked by sighting a plumb line against the beam from two positions, one in line with the axis, and one at right angles to it.

(4) *Focusing the projector.*—The first step in focusing the projector is to adjust the lamp with respect to the auxiliary reflector. The primary focusing assembly should be dismounted from the case of the projector. To adjust the center of the lamp filament to the central axis of the auxiliary reflector, loosen the machine screw marked "level adjusting screw." Move the lamp assembly up or down until the

center of the filament is at the central axis of the reflector, and tighten the adjusting screw. (See fig. 92.) Next, adjust the lamp to the focal point of the auxiliary reflector by loosening the nut on the screw marked "focusing adjustment," and moving the lamp closer to or farther from the reflector until the inverted image of the filament appears the same size as the filament itself, then tighten the nut down securely. The primary focusing assembly should now be adjusted properly and ready for mounting back in the projector case. A three-point support arrangement is provided for mounting this assembly in the projector housing and for focusing relative to the primary reflector. The three supporting studs are threaded into the housing and are provided with check nuts to permit locking the studs in position once the projector is focused. Two of these studs are located approximately 1½ inches from the center of the assembly, and their manipulation provides sideway motion for the bulb and auxiliary reflector. The third stud is located toward the rear of the projector, and its manipulation tilts the lamp assembly in or out toward the main reflector. When the check nuts are loose, these studs may be turned with a screw driver to accomplish the primary focus. In order to focus this assembly, it is necessary to level the projector housing so that the axis through the focal points of the primary reflector is horizontal. Then manipulate the three focusing studs until the most intense beam of light, with the narrowest divergence, is obtained. It is recommended that the beam be projected on a target approximately 200 feet away and arranged at the same height above the mounting level as the center of the reflectors. After the projector is satisfactorily focused, the check nuts should be tightened so that the adjusting studs cannot be moved readily out of position.

d. Use.—(1) *Clinometer.*—The clinometer is used to measure the angular elevation of a spot of light projected on the base of a cloud at night. (See fig. 93.) The sighting tube is nearly 3 inches in diameter at its outer end in order that not only the light spot on the cloud, but a portion of the surrounding dark sky as well, may be included in the field of view for contrast. A pair of cross wires aid the eye in centering on the light spot. A quadrant with scale 0° to 90°, in whole-degree graduations, is rigidly attached to the underside of the tube, and a pendant is pivoted on a horizontal axis in a way to permit it to hang vertically of its own weight when the tube is sighted on an object. The reference line on the pendant coincides with the zero line on the quadrant when the tube is sighted on an object at the same level, and coincides with the 90° line on the quadrant when it is

sighted on the zenith. A clutch, operated by turning a milled-head screw with the left hand, clamps the pendant in position when a sight is made. Three sights should be taken, and the average of the three used for calculating the height of the ceiling. When the clinometer is used, the ceiling-light projector is directed vertically or at some known angle of elevation. Using the length of the base line and the angle of elevation of the line of sight from the observing point, all necessary elements of the involved triangle are known. From these values, the height of the base of the cloud may be computed readily.

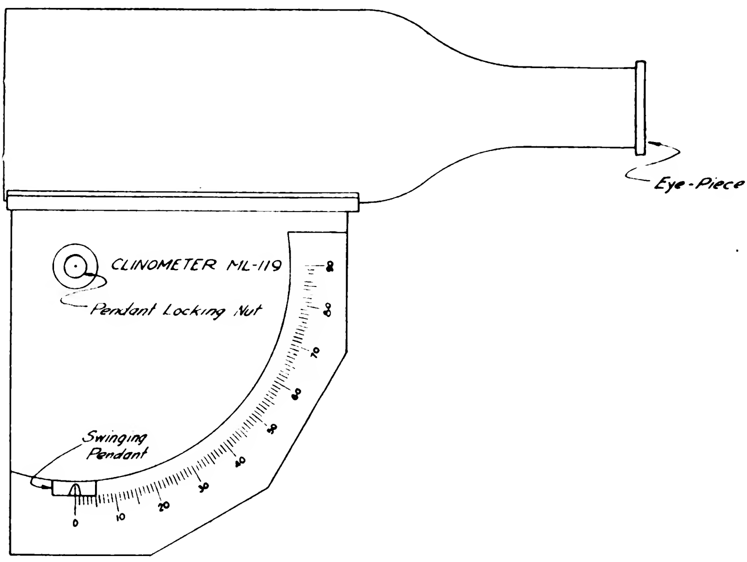


FIGURE 93.—Clinometer.

(2) *Measurement of ceiling without a clinometer.*—In the absence of a clinometer, the height of the cloud ceiling may be found by pacing off the distance from the projector to a point on the ground underneath the light spot on the zenith, the light beam from the projector being directed at an angle of either 45° or 63°26′ with the horizontal. For a 45° elevation, the distance is equal to the height of the ceiling; for a 63°26′ angle, the height is twice the distance paced. The arrangement of a ceiling-light projector and clinometer is shown diagrammatically in figure 94.

e. Care.—Only occasional cleaning of the glass reflectors is necessary on the ceiling light because of the weatherproof housing. Dirt and dust should be wiped off the projector glass cover at least once a week.

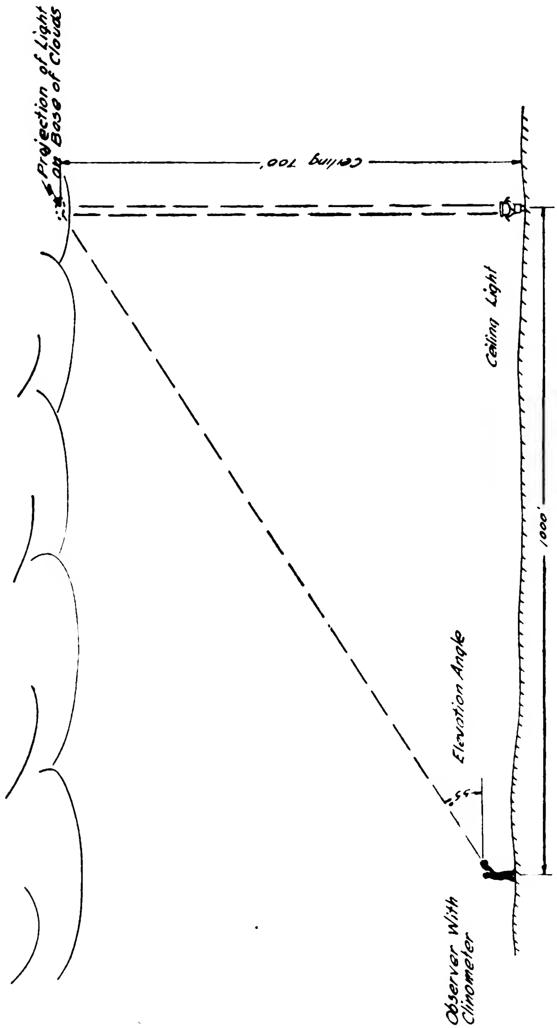


FIGURE 94.—Use of clinometer for measuring ceiling.

Care should be exercised to prevent keeping the projector light burning for long periods, as heat collecting in the housing may injure the glass reflectors.

Section II

SURFACE OBSERVATION

27. General.—*a. Definition.*—A surface weather observation is a collection of information describing the meteorological conditions present at a given station at the time of observation. Such observations form the bases for all teletype weather messages emanating from the station and for all voice-radio broadcasts of local weather conditions by local facilities and nearby transmitting units. They are, in other words, the principal source of weather information upon which incoming-aircraft flight plans are premised. A further purpose is served in furnishing a collected item of data, which, together with similar observations from other points, makes possible synoptic meteorological analyses. It is, therefore, not difficult to recognize the importance of an accurately accomplished "surface observation." Since the factors of which the surface observation is composed are subject to change, the least possible time consistent with accuracy must be consumed in working the observation. For the same reason, such elements as ceiling and visibility, which are obtained early in the observation and are of critical importance, should be subjected to careful verification at the completion of that portion of the observation which is made outdoors.

b. Elements of a complete surface weather observation.—(1) The following list is composed of those elements of a complete surface observation which are directly observed:

(*a*) Clouds.
(*b*) Ceiling.
(*c*) Visibility.
(*d*) Minimum temperature.
(*e*) Maximum temperature.
(*f*) Temperature.
(*g*) Wet-bulb temperature.
(*h*) Thermograph reading.
(*i*) Hydrograph reading.
(*j*) Amount of precipitation.
(*k*) Depth of snow.
(*l*) Weather and/or obstructions to visibility.
(*m*) Wind.
(*n*) Temperature of barometer (attached-thermometer reading).
(*o*) Observed barometer reading.
(*p*) Barograph reading.
(*q*) Pressure tendency and amount of change.

(2) The following data are quantities derived from those elements listed in (1) above:

(*a*) Dew point.
(*b*) Relative humidity.
(*c*) Total barometer correction.
(*d*) Station pressure.
(*e*) Average of temperature 12 hours ago and at present.
(*f*) Sea-level pressure (inches).
(*g*) Sea-level pressure (millibars).
(*h*) Altimeter setting.

c. Order in which elements of a surface observation are obtained.—The elements of the observation are noted and computed in the order in which they are listed in *b* above. When an observation is taken which does not include all of the elements, the observed elements are observed in the same relative order, with the elements that are not required omitted.

d. Recording the observation.—For that observation made nearest 0800 LST, the data obtained are recorded directly on SC Form No. 2. This form permits entry of those quantities (such as readings of the maximum and minimum thermometers) whose principal utility lies in furnishing "extreme" values and in furnishing data for correction of the recording instruments. Normally, such elements are observed but once a day (at 0800 LST) although local requirements may necessitate additional observations of similar function. In addition, pertinent elements of these data for 0800 LST are transcribed to SC Form No. 94. All other observations may be entered on locally prepared forms, and the completed data are transcribed to Form No. 94 for composition of the teletype message and for record. Normally, the locally prepared form is not preserved.

e. *Time of observation.*—The time of the observation is the time at which the observation must be ready for use, and is stated to the nearest whole minute, local standard time. At most stations an observation is made at least once each hour. Local requirements, and the character of the weather and changes thereof, frequently dictate additional times at which observations must be made.

f. *Types of observations.*—It is imperative that the weather information from any reporting station equipped with teletype or radio facilities or both, be up-to-date at all times. For this reason the following "types" of observations required from such stations have been evolved:

(1) *Record observation.*—The "record" observation is the hourly observation taken at such a time as to permit participation in the National Communications Schedules for radio or teletype. It is regularly the first observation transmitted in each 60-minute period, beginning at 30 minutes past the hour. The "record" observation must furnish the following data: ceiling, state of the sky (cloudiness), visibility, weather, obstructions to visibility, sea level pressure, temperature, dew point, wind velocity and character, altimeter setting, pertinent information not available elsewhere under preceding items.

(2) *Check observation.*—The "check" observation is a comparison by actual observation of the existing values of ceiling, sky, visibility, weather, obstructions to vision, wind and altimeter setting, with those currently reported and in use. Such observations will be made at designated times between the hourly "record" observations so as to conform with local radio broadcasts. Their purpose is to determine whether there has been any change in the elements mentioned and to bring the data up to date. If no change has occurred, the current observation will continue to be used in broadcasts, with the time designated as that of the "check" observation. If the "check" observation indicates that conditions have changed, but not enough to warrant designation as a "special" observation (see (3) below), then these changed values will be used in place of those given in the current report until the next "record" or "special" observation. Whether change has occurred or not, such observations will be entered on Form No. 94.

(3) *Special observation.*—(*a*) A "special" observation is a new observation taken when a *marked* change in weather conditions, as delineated in (*b*) below, occurs. If such a change occurs at the time of a "record" observation, the observation becomes a "record special," and carries the designation of "special" when transmitted or broad-

cast. Since the majority of "special" observations will be made at times other than those of "record" observation, and weather changes requiring the filing of the "special" may not involve temperature, dew point, altimeter setting, and barometric pressure, these data may have the same value as in the last previous "record," "check," or "special" observation, unless one or more of the following changes occur, in which case the new values will be reported:

1. Temperature rises or falls at the rate of 10° or more per hour.

2. Altimeter setting is 0.02 of an inch or more different from that last reported.

3. Dew point changes 3° or more from the last reported value. It is not necessary to take a psychrometric reading for each special unless such a change is suspected.

(*b*) *Rules for making and filing special observations.*—A "special" observation will be made and filed whenever any of the following changes, or combinations of them, occur:

1. At stations within control zones, whenever the weather changes so as to result in a changed classification from that last reported.

2. At the beginning or ending of precipitation, indicating a change from a period of no precipitation to one with continuous or intermittent precipitation, and vice versa. Under showery conditions, it will not be necessary to report each beginning or ending unless the period between showers is longer than 15 minutes. When this period is less than 15 minutes, suitable entry will be made under remarks for any report.

3. At the beginning and ending of the occurrence of hail.

4. When a thunderstorm not previously reported occurs, or when one previously reported shows marked increase in intensity. Also at the cessation of a thunderstorm previously reported.

5. A change in cloudiness below 10,000 feet from "clear" (or few) to "broken" or from "scattered" to "overcast," and vice versa.

6. A change in cloudiness below 900 feet from "scattered" to "broken" and vice versa, except that at stations located within control zones, a change in cloudiness below 1,500 feet from "scattered" to "broken" and vice versa. Frequent fluctuations between scattered and broken clouds should be reported under "Remarks," and when so reported, a "special" for each brief change is not filed.

7. Whenever the ceiling lowers to below 500 feet or rises to above 500 feet, sufficiently to require reporting of a value of 400 feet or less, or 600 feet or more. If the ceiling is fluctuating between 400 and 600 feet so rapidly that filing of specials becomes impracticable, then the ceiling is characterized as "variable."
8. Beginning or ending of fog, ground fog, or ice fog.
9. Beginning or ending of thick or dense ground fog, thick or dense fog, thick or dense ice fog. (A change from thick to dense or the reverse, of the same type fog does not require a special.)
10. A change from one type to another type of fog.
11. A wind shift passes the station.
12. Beginning and ending of tornadoes, sandstorms, or duststorms, if observed within 7 miles of the station.
13. When the visibility lowers from 7 miles or more at the last previous observation to 3 miles or less.
14. When the visibility lowers from a value less than 7 miles at the last previous observation, by one-half or more. (A change in visibility from one-eighth mile to zero, is not included.)
15. When a visibility originally less than 4 miles increases to a value two or more times that last reported. (A change in visibility from zero to one-eighth mile is not included.)
16. During daylight hours, whenever the visibility lowers to less than 1 mile or rises to 1 mile or more. When visibility values are fluctuating rapidly within the range of ¾ to 1¼ miles, inclusive, so that the filing of a special for each brief change is impracticable, "variable" will be applicable.
17. During hours of darkness whenever the visibility lowers to less than 2 miles, or rises to 2 miles or more. When visibility values are fluctuating rapidly within the range, 1¾ to 2¼ miles, inclusive, so that the filing of a special for each brief change is impracticable, "variable" will be applicable.
18. A doubling of wind speed when the increase is to 30 miles per hour or more.
19. A marked shift in wind direction, particularly from east or south to west or south, accompanied by an increase in velocity.

20. A change in "station pressure" since the previous "record" or "special" observation taking place at the rate of 0.08 inch or more per hour. "Special" observations, due exclusively to rapid changes in pressure as specified, will be filed at 15-minute intervals as long as this rate of pressure change persists.

21. The conditions listed above will not cover all cases wherein a "special" observation should be filed. The intention is that any change of importance to the safety of air traffic will be reported as soon as it occurs.

(4) *Local extra observation.*—"Local extra" observations, composed of ceiling, sky, visibility, weather, obstructions to visibility, and remarks, will be made each 15 minutes, beginning with the first 15 minutes following a "record," "check," or "special" observation which shows a ceiling less than 600 feet or a visibility less than 1¼ miles, and continuing until an observation shows a ceiling of 600 feet or more and a visibility of 1¼ miles or more.

28. Clouds.—A complete observation of clouds must include the amount of cloudiness, heights of the clouds, types of clouds present, direction of motion of the clouds, and an indication of the appearance of the sky as a whole with reference to clouds.

a. Amount of cloudiness.—The amount of cloudiness is indicated as the fractional part of the dome of the sky obscured by clouds; or as being clear, having scattered clouds, or broken clouds; or being overcast.

(1) *Numerical indication of cloudiness.*—The amount of cloudiness is indicated as the fractional part of the entire dome of the sky occupied by clouds. The fraction is expressed as the nearest whole number of tenths, with the decimal point (or denominator) omitted. Thus the figure "7" would indicate that seven-tenths of the sky is occupied by clouds. Whenever clouds are present, but the amount is closer to 0 than to 1, the cloudiness is characterized as "few." Whenever clouds do not completely cover the sky, but still are closer to 10 than to 9, the cloudiness is characterized as "overcast with breaks." When the amount of cloudiness is indicated by numbers as described above, reference is made only to the amount of cloudiness actually visible. When clouds are recorded according to type, the amount of clouds of that type is recorded at the same time, and the numerical indications shown above are used. If only cumulus clouds and cirrus clouds are visible in the sky, and they cover three-tenths and five-tenths of the sky, respectively, two-tenths of the sky would be blue. The clouds recorded by type would appear as 5 Ci, 3 Cu.

(2) *Indication of cloudiness by "sky condition."*—There are four basic descriptive terms employed in indicating cloudiness by stating the "sky condition." These terms and the symbols representing them are as follows:

Clear	○	when total cloudiness is less than 1.
Scattered	⦶	when total cloudiness is 1 to 5, inclusive.
Broken	⦷	when total cloudiness is 6 to 9, inclusive.
Overcast	⊕	when total cloudiness is more than 9.

Since cloudiness is not confined to one level, simple employment of the terms listed above is frequently inadequate to lend a complete description of the actual state of the sky with respect to cloudiness. The use, then, of combinations of these terms and symbols to represent more than one layer of clouds is indicated. To clarify further the meaning of these combinations, modifying terms and symbols are used. Since, so far as flying operations are concerned, cloudiness occurring above about 10,000 feet is of less importance than that occurring below that level, all such cloudiness is figuratively grouped together as one layer for descriptive purposes. Actually, the figure fixed upon is 9,750 feet, and any cloudiness above that level is referred to as "high." Cloudiness below 9,751 feet is referred to as "lower." Whenever "high" cloudiness occurs, either in combination or singly, the modifying term "high" will be used with the state of the sky above 9,750 feet, as, "high scattered, lower scattered" ⦶/⦶, or simply "high scattered" ⦶/. The symbol /, following the state of the sky above 9,750 feet, is used to indicate that the cloudiness referred to is above that level. This practice is adhered to regardless of the state of the sky below 9,751 feet. The slant mark is not used in the absence of "high" cloudiness. When a layer of clouds below 9,751 feet occurs singly, the modifying term "lower" is omitted and the lack of any modifying term will in itself denote the fact that the clouds are below 9,751 feet. When a cloud layer below 9,751 feet is described in combination with a "high" layer, the term "lower" will always be employed, as "high scattered, lower broken" ⦶/⦷. However, when such a layer is described in combination with a second layer, also below 9,751 feet, the term "lower" will be used only with the lower of two such layers, as "broken, lower broken" ⦷⦷. No more than two sky conditions will be grouped together to form the final descriptive term. The following examples of combination descriptive terms are furnished for information and guidance:

Symbol	Descriptive phrase	Condition represented
⦶/	High scattered clouds	All cloudiness is above 9,750 feet; total cloudiness is one-tenth to five-tenths, inclusive.
⦷/	High broken clouds	All cloudiness is above 9,750 feet; total cloudiness six-tenths to nine-tenths, inclusive.
⊕/	High overcast clouds	All cloudiness is above 9,750 feet; total cloudiness more than nine-tenths.
⊕/⦶	High overcast, lower scattered clouds.	One layer above 9,750 feet and one below; lower cloudiness is one-tenth to five-tenths, inclusive, and total of tenths covered is over nine.
⊕/⦷	High overcast, lower broken clouds.	One layer above 9,750 feet and one below; lower layer is over five-tenths, but not more than nine-tenths, and total of tenths covered is over nine.
⦷/⦶	High broken, lower scattered clouds.	One layer above 9,750 feet and one below; lower layer is from one-tenth to five-tenths inclusive, and total of tenths covered is from six to nine inclusive.
⦷/⦷	High broken, lower broken clouds.	One layer above 9,750 feet and one below; lower layer is from six-tenths to nine-tenths, inclusive, and total of tenths covered is from six to nine inclusive.
⦶/⦶	High scattered, lower scattered clouds.	One layer above 9,750 feet and one below; total cloudiness does not exceed five-tenths, and each layer separately covers one-tenth or more.
⦶/⦷	High scattered, lower broken clouds.	One layer above 9,750 feet and one below; lower layer is over five-tenths but not more than nine-tenths, and it is clearly evident to the observer that the high layer is "scattered."
⊕⦶	Overcast, lower scattered clouds.	Two layers below 9,751 feet; lower layer is one-tenth to five-tenths inclusive, and total of tenths covered is over nine.
⊕⦷	Overcast, lower broken clouds.	Two layers below 9,751 feet; lower layer is from six-tenths to nine-tenths inclusive, and total of tenths covered is over nine.
⦷⦶	Overcast, lower scattered clouds.	Two layers below 9,751 feet; lower layer is from one-tenth to five-tenths inclusive, and total of tenths covered is from six to nine inclusive.
⦷⦷	Broken, lower broken clouds.	Two layers below 9,751 feet; lower layer is from six-tenths to nine-tenths inclusive, and total coverage does not exceed nine-tenths.

Symbol	Descriptive phrase	Condition represented
⦶⦶	Scattered, lower scattered clouds.	Two layers below 9,751 feet; lower layer is from one-tenth to five-tenths inclusive, and total coverage does not exceed five-tenths.
⦶ ⦷	Scattered, lower broken clouds.	Two layers below 9,751 feet; lower layer is from five-tenths to nine-tenths, and it is *clearly* evident to the observer that the upper deck is "scattered."

b. Height of clouds.—(1) *Definition.*—The height of clouds is the elevation of the bases of the clouds above the ground. The height is recorded to the nearest 100 feet when the cloud bases are below 5,000 feet; when the clouds are above 5,000 feet, the height is recorded to the nearest 500 feet. When the height is entered on Weather Service forms, the last two zeros are omitted, and the height is thus expressed in hundreds of feet.

(2) *Measurement and estimation of cloud heights.*—(*a*) *Pilot balloons.*—Pilot balloons may be used to measure cloud heights. A properly inflated balloon rises at a known rate. The table below gives the height of the pilot balloon for each minute after its release. This table is based on a free lift of 4.66 ounces for a hydrogen-filled balloon. The observer notes the time of release of the pilot balloon and the time at which it enters the cloud base. Corresponding to the time interval that elapses, is the height of the balloon, and therefore the bases of the cloud. When necessary, interpolation is used to determine the height.

Rate of ascent of 1.06 ounce balloon with 4.66 ounces of free lift

Minutes after release	Height of balloon in yards	Minutes after release	Height of balloon in yards	Minutes after release	Height of balloon in yards
1	240	11	2, 300	21	4, 300
2	460	12	2, 500	22	4, 500
3	680	13	2, 700	23	4, 700
4	890	14	2, 900	24	4, 900
5	1, 100	15	3, 100	25	5, 100
6	1, 300	16	3, 300	26	5, 300
7	1, 500	17	3, 500	27	5, 500
8	1, 700	18	3, 700	28	5, 700
9	1, 900	19	3, 900	29	5, 900
10	2, 100	20	4, 100	30	6, 100

(*b*) *Ceiling light*.—The ceiling light is used to measure the height of clouds at night. The observer, standing at a specified distance from the light, measures the angle of elevation of the part of the cloud illuminated by the light. The vertical angle is measured with a clinometer. Each weather station where a ceiling light is used, has a table of cloud heights which correspond to elevation angles.

(*c*) *Pilot's reports*.—When a pilot's report relative to the height of the base of a layer of clouds is available, it may be used in reporting the height of clouds. Such reports are based on altimeter readings obtained upon entering or leaving the cloud layer.

(*d*) *Estimation*.—When no measured value for the height of clouds is available, the height must be estimated. In estimating the height of clouds the observer may be guided by estimating the change in height since the height of the same clouds was last measured. When the clouds cut off nearby mountains or tall buildings, these facts may be used in making an estimate of cloud height. The average height of the observed type of cloud, together with its appearance, may be used in estimating the height of the cloud base. When cumulus clouds are in the sky at midday, the height of their bases may be estimated from the temperature and dew point of the air at the surface. This rough estimate is made by finding the difference between the air temperature and the dew point, in degrees Fahrenheit, and multiplying that difference by 235. The product is the estimate of height in feet.

(3) *Ceiling*.—The ceiling is the lowest height above the ground at which, and below which, the total amount of cloudiness constitutes broken ⦶ or overcast ⊕; i. e., the amount of cloudiness at and below that height is six-tenths or more. When an observation of the amount of cloudiness is prevented by heavy precipitation, dense fog, or other weather conditions, the ceiling is zero. When the height, defined above, is greater than 20,000 feet, the ceiling is "unlimited"; when the height is 10,000 feet or more, the ceiling is considered "high," and will be reported as "unlimited" in all teletype or radio weather messages. Absence of broken or overcast clouds also constitutes an unlimited ceiling. Unlimited ceiling heights (greater than 20,000 feet) are indicated on Weather Service forms by the absence of an entry in the ceiling space. When entry of ceiling height is made, an estimate must be indicated by an "E" immediately preceding the ceiling height, without space. The absence of an "E" with the ceiling height indicates that the height is a measured one.

(4) *Reporting.*—Ceiling heights and heights of "lower" clouds are indicated habitually whenever cloudiness is reported in terms of sky conditions. The ceiling invariably precedes all sky symbols and refers to the lowest reported clouds that are broken ⦷ or overcast ⊕. Other cloud heights are recorded immediately preceding the cloud symbol to which reference is intended. When two "lower" scattered cloud layers are reported, only the lower of the two is accompanied by an indicated height. In those cases wherein a ceiling height is reported, no cloud height above the ceiling is reported. A number of examples illustrating the practice described above follow:

E45⊕⦷	Ceiling 4,500 feet (estimated height of layer); above the ceiling.
45⊕20⌽	Ceiling 4,500 feet (measured height of layer); layer at 2,000 feet.
E23⊕/⦷	Ceiling 2,300 feet (estimated height of layer); layer above 10,000 feet.
⌽/25⌽	Ceiling unlimited; high scattered, lower scattered clouds at 2,500 feet.
25⌽	Ceiling unlimited; scattered clouds at 2,500 feet.

c. Types of clouds.—(1) *Families.*—All clouds are divided among four families, according to the range of height within which they usually occur.

(*a*) *High* (*cirrus*) *clouds.*—The cirrus family includes cirrus, cirrocumulus, and cirrostratus clouds. The mean lower level of cirrus family clouds is 20,000 feet; they may be much higher.

(*b*) *Middle clouds.*—The family of middle clouds comprises altostratus and altocumulus clouds. They range from a mean lower level of 6,500 feet to a mean upper level of 20,000 feet.

(*c*) *Low clouds.*—Cloud types which are in the low-cloud family are stratocumulus, stratus, and nimbostratus. They range from a mean lower level close to the ground to a mean upper level of 6,500 feet.

(*d*) *Clouds with vertical development.*—Clouds in this family are cumulus and cumulonimbus. Their range of height is from a mean lower level of 1,600 feet to a mean upper level at the top of the troposphere.

(2) *Major types.*—Clouds are further divided into ten major types, according to the appearance of their structure and their height.

(*a*) *Cirrus.*—Cirrus clouds are detached clouds of delicate and fibrous appearance, without shading, generally white in color, often of a silky appearance. Cirrus clouds are always composed of ice

crystals, and their transparent character depends on the degree of separation of the crystals. As a rule, when these clouds cross the sun's disk, they hardly diminish its brightness; but when they are especially thick, they may veil its light and obliterate its contour. Thin patches of altostratus cloud may similarly veil the sun's light, but they are distinguished by the absence of the dazzling and silky white edges that occur with cirrus. Before sunrise and after sunset cirrus clouds are often colored bright yellow or red. These clouds are lighted up much earlier and fade out much later than other clouds; some time after sunset they become gray. At all hours of the day cirrus clouds near the horizon often have a yellowish color; this is due to the great thickness of the air traversed by light from the cloud.

(b) *Cirrocumulus.*—Cirrocumulus clouds are small, white masses of cloud, globular or flakelike in appearance, usually without shadows. They are ordinarily part of a patch or layer and are arranged in groups or rows, often so close together as to appear like ripples in a continuous cloud deck similar in appearance to ripples on the sand of a beach. Altocumulus clouds, a more common type than cirrocumulus, often have the same appearance as cirrocumulus. Certain characteristics of cirrocumulus clouds differentiate them from altocumulus clouds. In the absence of any such characteristics, clouds that look like cirrocumulus and like altocumulus are to be identified as altocumulus. When any one of the characteristics of cirrocumulus clouds is shown by such clouds, they shall be identified as cirrocumulus. The following are characteristic conditions of cirrocumulus clouds which distinguish them from altocumulus:

1. There is an evident connection between the clouds in question and cirrus or cirrostratus clouds.
2. The clouds in question are evidently higher than some cirrus or cirrostratus clouds.
3. The clouds in question are evidently a result of development from cirrus or cirrostratus clouds.
4. The cloud in question exhibits halo phenomena.

(c) *Cirrostratus.*—A cirrostratus cloud is a cloud in the form of a thin, whitish veil which does not blur the outlines of the sun or moon, but which usually gives rise to halos. Sometimes it is quite diffuse and merely gives the sky a milky look; sometimes it shows a fibrous structure with disordered filaments. The sheet is never so thick as to prevent the sunlight's coming through sufficiently for terrestrial objects to cast shadows on the ground. A milky veil of fog, stratus, or thin altostratus is distinguished from cirrostratus by the absence

of halo phenomena which the sun or moon very often produces in cirrostratus cloud. The following are the principal halo phenomena

1. A circle around the sun or moon whose radius subtends an angle of 22°. This is closely equal to the angle subte[illegible] by the width of one's extended hand at an exte[illegible] arm's distance from the eye.
2. A similar circle whose radius subtends an angle of 46°.
3. Parhelia and paraselenae (mock suns and mock moons) [illegible] other luminous patches, often showing prismatic co[illegible] a little over 22° from the sun and at the same elevat[illegible]
4. A luminous column, or sun pillar, extending vertically al[illegible] and below the luminary.

(d) *Altocumulus.* Altocumulus clouds are small masses of cl[illegible] shaped like laminae or flattened globules. They appear in laye[illegible] patches arranged in rows, groups, or waves. The waves or rows m[illegible] extend in two directions, causing a checkerboard effect. At lo[illegible] levels where altocumulus may be derived from the spreading ou[illegible] cumulus clouds they may resemble stratocumulus clouds. The co[illegible] [illegible] that clouds are altocumulus if the smallest well defined regularly arranged elements in the layer (not considering the detached elements which are generally seen around the edges) [illegible] smallest diameters. [illegible] when the arm is fully [illegible] smallest well-defi[illegible] [illegible]

FIGURE 95.—Cirrus clouds.

FIGURE 96.—Cirrus clouds.

FIGURE 97.—Cirrocumulus clouds.

FIGURE 98.—Cirrocumulus clouds.

Figure 99.—Cirrostratus clouds.

Figure 100.—Cirrostratus clouds (with halo).

FIGURE 101.—Altocumulus clouds.

FIGURE 102.—Altocumulus clouds.

FIGURE 103.—Altocumulus clouds.

FIGURE 104.—Altocumulus clouds (with virga).

FIGURE 105.—Altostratus clouds (with fractostratus).

FIGURE 106.—Altostratus clouds.

Figure 107.—Stratocumulus clouds.

Figure 108.—Stratocumulus clouds.

FIGURE 108.—Stratus clouds (under altostratus overcast).

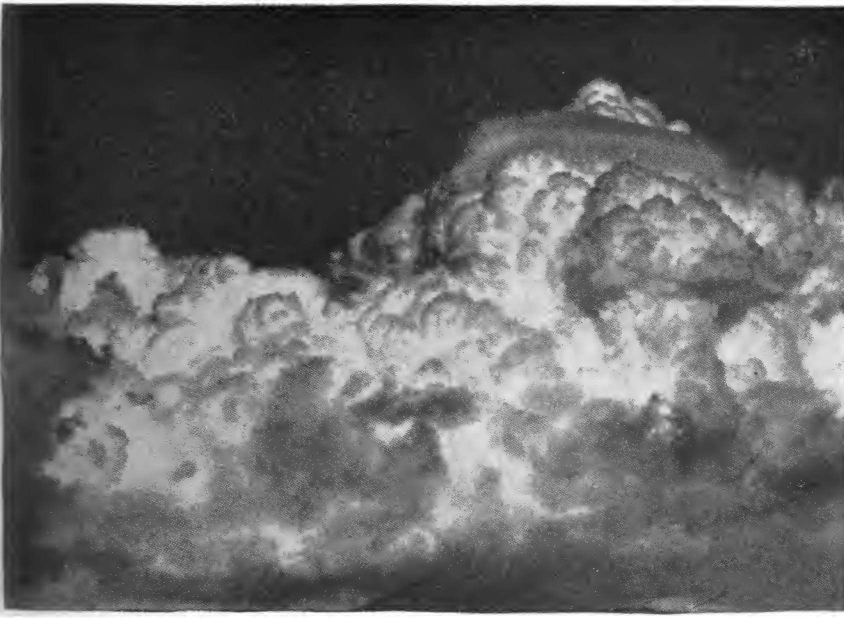


FIGURE 111.—Cumulus clouds (with pileus).

FIGURE 112.—Cumulus clouds.

FIGURE 113.—Fractocumulus clouds.

FIGURE 114.—Fractocumulus clouds.

FIGURE 115.—Cumulonimbus clouds.

FIGURE 116.—Cumulonimbus clouds.

The thickness of altostratus cloud ordinarily varies from one part of the sky to another, but never shows any relief; i. e., its bottom surface is always flat. Light to moderate rain or an intensity of snow may fall from altostratus clouds. When heavy rain occurs and altostratus clouds have been previously observed, the heavy rain is an indication that the clouds have changed from altostratus to nimbostratus. Showers of rain or snow do not fall from altostratus clouds.

(*f*) *Stratocumulus.*—Stratocumulus clouds are cloud masses shaped like laminae globular masses or rolls, arranged in layers or patches. The smallest of the regularly-arranged elements of the cloud deck are fairly large. The edges of stratocumulus clouds are not sharply defined, and their gray color varies from one part of the layer of cloud to another. Stratocumulus clouds may appear as a continuous sheet with distinct irregularities, or rolls, of large size. Very often the rolls are so close together as to leave no interstices, and only a wavy appearance remains. The elements of a stratocumulus cloud deck may be arranged in nearly uniform patterns of dark gray.

(*g*) *Stratus.*—Stratus cloud is a low, uniform layer or blanket of cloud that resembles fog, but does not reach the ground. A veil of stratus cloud gives the sky a hazy appearance. Precipitation from stratus cloud is only in the form of drizzle or frozen drizzle. However, other forms of precipitation may fall from some cloud above the stratus through the stratus cloud.

(*h*) *Nimbostratus.*—Nimbostratus cloud is a low, amorphous layer of cloud which very often is the source of precipitation. Its appearance is dark gray and very nearly uniform. Nimbostratus cloud results from the lowering and thickening of altostratus cloud. It is the most common source of heavy, continuous rain and snow. Moderate and light precipitation, generally continuous, fall from nimbostratus. Often nimbostratus cloud occurs without any precipitation.

(*i*) *Cumulus.*—Cumulus clouds are dense clouds with vertical development. The upper surface is roughly dome-shaped and has rounded protuberances; the base is nearly flat and horizontal. The edges of cumulus clouds, especially on the upper surface, are sharply defined. When a cumulus cloud is opposite the sun, the surfaces facing the observer are brighter than the edges; when the sun lights the cloud from the side, strong contrasts of light and shade are visible; when the sun is behind a cumulus cloud, the edges appear brightest. A cumulus cloud generally has a gray base and uniform structure of rounded parts up to its summit; no fibrous structure is apparent. However, when the tops of cumulus clouds reach the altocumulus level, a light, diffuse, white veil sometimes develops over them. This veil.

known as pileus, is a lenticular cloud with a delicate striated or flaky structure. Often the pileus is shaped like a dome and may cover the tops of several cumulus clouds.

(*j*) *Cumulonimbus.*—Cumulonimbus clouds are heavy masses of cloud with great vertical development whose cumuliform summits rise in the form of mountains or towers and whose upper parts have a fibrous texture and often spread out in the form of an anvil. The universal characteristic of cumulonimbus clouds is the fibrous texture of the upper parts. These fibrous parts are a variety of cirrus clouds and are not to be confused with pileus which may occur with either cumulonimbus or cumulus clouds. Cumulonimbus clouds generally produce showers of rain or snow. Sometimes they develop sufficiently to cause thunderstorms and hailstorms. The occurrence of thunderstorms, hail, moderate or heavy showers of rain or snow is conclusive evidence of the presence of cumulonimbus clouds. The underside of cumulonimbus cloud resembles that of nimbostratus. Furthermore, when either cumulonimbus or nimbostratus cloud is well developed, it is accompanied by low, ragged clouds underneath. When sufficient information from the appearance of the cloud is not available, its type must be determined from such evidence as precipitation, present and recent, the presence or absence of thunder or lightning, etc.

(*k*) *Abbreviations.*—Abbreviations are always used in making record of clouds. Below are listed the standard abbreviations for the names of the 10 major cloud types:

Cirrus—Ci	Stratocumulus—Sc
Cirrocumulus—Cc	Stratus—St
Cirrostratus—Cs	Nimbostratus—Ns
Altocumulus—Ac	Cumulus—Cu
Altostratus—As	Cumulonimbus—Cb

(3) *Additional subtypes of clouds.*—In addition to the 10 major types of clouds there are several especially noteworthy subtypes. These are recorded just like the major types of clouds whenever they occur.

(*a*) *Altocumulus castellatus.*—Altocumulus castellatus clouds are a special type of altocumulus clouds. They differ from other altocumulus clouds in that they have some appreciable vertical development upward from a layer of altocumulus. They are usually arranged in lines, and they appear like rising towers or battlements of cloud.

(*b*) *Fractostratus.*—Fractostratus clouds are very low, irregular, formless shreds of cloud. Their color is dark gray. They result from the breaking up of a sheet of stratus cloud or they may be a state in the formation of stratus cloud, the fractostratus forming and then amalgamating into one sheet.

(*c*) *Fractocumulus.*—Fractocumulus clouds are low, irregular clouds which have some cumuliform appearance. This cumuliform appearance, their vertical development, distinguishes them from fractostratus.

(*d*) *Cumulonimbus mammatus.*—Cumulonimbus mammatus clouds are cumulonimbus clouds whose undersurfaces (the base or the underside of the anvil) have a billowy appearance. The appearance of sacks or breasts protruding from the undersurface of a cloud characterizes that cloud as a mammatus variety.

(*e*) *Abbreviations.*—Abbreviations are used in recording subtypes of clouds just as they are used for the 10 major types. The abbreviations for the names of the subtypes of clouds are:

Altocumulus castellatus—Acc
Fractostratus—Fs
Fractocumulus—Fc
Cumulonimbus mammatus—Cm

(4) *Direction of movement of clouds.*—The direction of movement of clouds is the direction from which the clouds are moving. The direction of movement is given to the nearest of the eight points of the compass, regular English abbreviations being used. For the direction of movement of clouds showing no perceptible motion, "O" is entered on Weather Service forms. Whenever the direction of motion cannot be determined, "u" is entered.

(*a*) *Direction of cloud movement from pilot-balloon soundings.*—When, during a pilot-balloon sounding, the balloon enters the base of some clouds, the horizontal direction of motion of the balloon is the same as the direction of movement of the clouds. When the height of a layer of clouds is known, the direction of movement is given by the wind direction at that level, as computed from a pilot-balloon sounding.

(*b*) *Direction of motion from readings of a theodolite.*—In determining the direction of movement of a cloud, the observer notes the vertical and azimuth angles of a prominent part of the cloud in two successive positions. Assuming an arbitrary height for the cloud, the horizontal projections of the two successive positions are plotted on the regular pilot-balloon plotting board. The same height must be used for both positions. The direction of the first point from the second gives the direction of motion of the cloud. In plotting the horizontal projections the horizontal distance is taken from Tables of Vertical and Horizontal Components of Distances of Pilot Balloons, the height being the arbitrary height chosen.

(*c*) *Direct observation of movement of clouds.*—In directly observing the direction of movement of clouds, the observer watches the motion of a prominent part of the cloud relative to some fixed point near it (e.g., stars, sun, or moon, top of flagpole, corner of building). The motion of clouds directly overhead or nearly so is more apparent than the motion of one cloud nearer the horizon. The motion of one cloud in a layer is representative, ordinarily, of the motion of the entire layer. Thus, the observer should choose one of the clouds near the zenith in getting the motion of a layer of clouds.

(5) *State of the sky.*—The state of the sky represents the appearance of the sky as a whole. It is given by the state of the sky with respect to low clouds, with respect to middle clouds, and with respect to high clouds. These are represented symbolically as C_l, C_m, and C_h. There are ten different states of the sky for each of these levels, and they are represented as $C_l=0$, $C_l=1$, $C_l=2$. . . $C_l=9$; $C_m=0$, $C_m=1$, $C_m=2$ . . . $C_m=9$; and $C_h=0$, $C_h=1$, $C_h=2$ . . . $C_h=9$. Whenever the state of the sky can be properly represented by more than one classification for any one level, that classification which is designated by the higher number is the one used. Thus, if both $C_h=1$ and $C_h=9$ classifications coincide with the appearance of the sky, $C_h=9$, and that alone for the C_h designation, will be recorded. The state of the whole sky is given by a combination of the state of the sky at each level and is represented symbolically as C_l, C_m, and C_h. There are, therefore, a maximum of 1,000 different states of the sky as a whole.

(*a*) *State of the sky with respect to low clouds.*—*1. $C_l=0$: no low clouds in the sky.*

2. $C_l=1$: cumulus of fine weather.—Cumulus clouds of fine weather are observed in several forms. They may be forming, usually in the morning; they may be completely formed, usually at about midday, having definite, horizontal bases and being either flat and deflated or with rounded tops (no cauliflower shape); they may be formed but broken up by the wind (fractocumulus). The fractocumulus clouds of fine weather noted above and coded as $C_l=1$, must not be confused with the fractocumulus of bad weather which is coded $C_l=6$, or $C_l=9$. The former, $C_l=1$, are detached white clouds, usually in a blue sky, and remain detached; the latter are found in the central part of a distrubance or in its rear. Bad-weather fractocumulus clouds form in the first case ($C_l=6$) under a gray sheet of altostratus or of nimbostratus; in the second case ($C_l=9$), in a sky crowded

with clouds at all altitudes. They may form under the bases of cumulonimbus or very large cumulus clouds, or in the spaces between these. In both cases they are dark, receiving little light, and generally become very numerous; while the fractocumulus clouds of fine weather are usually snow white on a blue sky and remain detached.

3. *C_l=2: cumulus, heavy and swelling, without anvil top.*—Clouds classified as C_l=2 may form in calm air, especially on hot days. They have a heavy appearance, with flat bases and very great vertical development. They are sometimes in the form of towers, sometimes in the form of complex heaps with "cauliflower" formation. They often have caps or heads, i.e., pileus. When C_l=2 occurs on windy days, the clouds are somewhat broken up. None of the clouds in the sky characterized as C_l=2 may have ice crystal clouds at the tops. The appearance of such fibrous parts indicate that the cloud is a cumulonimbus, C_l=3.

4. *C_l=3: cumulonimbus clouds of great vertical development, with the tops composed of ice-crystal clouds.*—Sometimes the nascent ice-crystal cloud is merely mingled with the "cauliflower" tops, where a fibrous structure appears and the clear-cut outlines fray out; sometimes the completely formed ice-crystal clouds crown the cumulus with a definite plume of cirrus, of a shape more or less like that of an anvil. Sometimes, especially in the spring and in the high latitudes, the ice-crystal formation involves nearly the whole cloud, even to the base. At the end of the growth of a cumulonimbus the lower cumuliform part of the cloud often tends to disappear, leaving only the upper or cirrus part. When the anvil, reaching nearly to the zenith, begins to overshadow the observer, a mammatus structure will often be seen on the lower surface of the anvil projection. Like the heavy and swelling cumulus, cumulonimbus is formed either in calms, especially on hot, thundery days, or in a strong wind in the rear of disturbances. Cumulonimbus is a regular factory of clouds. By extension at various levels, it often produces either cirrus masses by an extension of the ice-crystal parts, or masses of altocumulus or stratocumulus by an extension of the cumuliform parts, and

these may end by becoming detached from the parent cloud. Thus, cumulonimbus, $C_l=3$, may coexist with cloud sheets that should be coded $C_h=3$ or $C_m=6$. At the end of the evolution of cumulonimbus, $C_l=3$ should be coded only when the cumuliform parts are still visible. When the cumuliform clouds have degenerated, the anvil top, or the clouds derived therefrom, should be coded $C_h=2$. When cumulonimbus nears the zenith, and its base, with low, dark underlying clouds often in the form of a roller or an arch, has covered all or nearly all the sky, code $C_l=3$ should be replaced by $C_l=9$.

5. *$C_l=4$: stratocumulus, formed by the flattening of cumulus clouds.*—$C_l=4$ represents stratocumulus clouds which form either due to dissipation of cumulus cloud at the top and spreading out at the bottom, or due to spreading out of the cumulus at the top while the lower parts dissipate.

6. *$C_l=5$: layer of stratus or stratocumulus.*—These are clouds usually forming a single layer, fairly regular and not very dark or menacing. They have a certain stability. The stratocumulus has often semitransparent parts, or even clear spaces between the elements of the cloud. The layer of stratocumulus may often be broken up. Code $C_l=5$ is used only for those sheets of stratocumulus that are not formed from cumulus; otherwise they are coded $C_l=4$. The observer may be in doubt between $C_l=5$ and $C_m=3$. The code $C_l=5$ is used only when the stratocumulus is fairly low and rather like stratus (large and rather diffuse tesselations or waves). If it is clearly high and related to altocumulus, it is coded $C_m=3$.

7. *$C_l=6$: low, broken-up clouds of bad weather.*—The following is the ordinary course of formation of these clouds: When a veil of altostratus becomes lower and tends to turn into nimbostratus, it usually has below it a gradually increasing layer of fractocumulus or fractostratus. These clouds are isolated at first. They ultimately fuse into a continuous sheet, but through interstices the veil of relatively light, higher clouds may be seen. Continuous rain does not usually occur until after formation of the fractostratus or fractocumulus, which is then hidden by the precipitation or may even disappear under its influence.

8. *$C_l=7$: cumulus of fine weather, and stratocumulus.*—The clouds represented by $C_l=7$ are a sheet of stratocumulus with some cumulus cloud formed underneath. These cumulus clouds must not have any great vertical development. Also, they must not penetrate the layer of stratocumulus clouds; otherwise they would be classified as $C_l=8$.

9. *$C_l=8$: heavy or swelling cumulus, or cumulonimbus, and stratocumulus.*—The clouds represented by $C_l=8$ are a sheet of stratocumulus with some well developed cumulus underneath. The clouds underneath must have great vertical development visible to the observer, or they must penetrate the stratocumulus deck, to be classified as $C_l=8$.

10. *$C_l=9$: heavy or swelling cumulus or cumulonimbus and low, ragged clouds of bad weather.*—When low, ragged clouds of bad weather are present at the same time as cumulus that has great development, or cumulonimbus, the sky is represented by $C_l=9$. It is not necessary that the observer actually see the cumulus or cumulonimbus. It is sufficient that he knows that either of these clouds are present. Showers, thunder, or hail are good enough evidence, in the presence of low, ragged clouds, to classify the sky as $C_l=9$.

(*b*) *State of the sky with respect to middle clouds.—1. $C_m=0$: no middle clouds visible.*—When no middle clouds are visible, due either to their absence or to their being totally obscured by lower clouds, the state of the sky with respect to middle clouds is given as $C_m=0$.

2. *$C_m=1$: typical thin altostratus.*—In classifying clouds as $C_m=1$, caution must be taken not to confuse cirrostratus cloud with altostratus. The criteria of altostratus cloud are absence of halo phenomena, appearance of the sun shining through as through ground glass, and absence of sufficient light to cause terrestrial objects to cast shadows.

3. *$C_m=2$: typical thick altostratus or nimbostratus.*—Thick altostratus clouds are thick enough, at worst, so that the sun or moon is completely hidden by the thicker parts of the cloud sheet. The undersurfaces of both the nimbostratus and the thick altostratus must be flat,

Detached masses						Sheet or layer				
With vertical development			Without vertical development			Single layer of stratus or stratocumulus	Low clouds of bad weather fused into continuous sheet	Stratocumulus with fair weather cumulus below	Stratocumulus with towering cumulus below or with cumulus or cumulonimbus penetrating the layer	Cumulonimbus covering the sky with ragged low clouds of bad weather below
Small, with slight vertical development (typical fair weather type)	Active vertical growth without fibrous summit	Great vertical growth with fibrous summit	Spread out from cumulus	Low bad weather clouds						
				Under altostratus or nimbostratus	Under cumulonimbus					
L_1	L_2	L_3	L_4	L_6	L_9	L_5	L_6	L_7	L_8	L_9

FIGURE 117.—State of the sky for lower clouds.

with no real relief. Should there be some wavy structure, the clouds would be classified as $C_m=7$. Thick altostratus and nimbostratus clouds are often accompanied by low, broken-up clouds of bad weather. Thus the occurrence together of $C_l=6$ and $C_m=2$ is to be expected often.

4. *$C_m=3$: altocumulus or high stratocumulus.*—These clouds are usually in a single layer, and do not show a tendency to increase in amount. The layer is fairly regular and of uniform thickness. The cloudlets are fairly small and light, being separated by clear spaces or lighter gaps. This layer of cloud is sometimes broken up, but it is coded as $C_m=3$ only if the clouds do not proceed from extensions of the tops of cumulus clouds. When altocumulus clouds do extend from the tops of cumulus clouds, they are properly classified as $C_m=6$. Clouds represented by $C_m=3$ do not exhibit a tendency to increase. Clouds which appear like $C_m=3$, but show a tendency to increase, are properly classified as $C_m=5$. Stratocumulus clouds included in the designation $C_m=3$ must be high and fairly small; otherwise they would properly be classified as $C_l=6$.

5. *$C_m=4$: altocumulus clouds in small, isolated patches, individual clouds often showing signs of evaporation and being more or less lenticular in shape.*—Clouds classified as $C_m=4$ are generally scattered quite irregularly over the sky, often at different levels, and are constantly changing their appearance. Individually they are often in a process of dissolution, but the amount of cloudiness over the sky in general does not become greater or less. The smallness and the whiteness of the cloudlets make them appear much like cirrocumulus, but they lack the distinguishing halo phenomena and connections with other cirriform clouds. Irisations are usual with clouds indicated by $C_m=4$. To distinguish between these clouds and other middle clouds, it may be noted that $C_m=4$ represents clouds that do not have the regular structure of $C_m=5$; they are higher and more delicate than clouds classified as $C_m=6$.
6. *$C_m=5$: altocumulus arranged in more or less parallel bands or an ordered layer advancing over the sky.*—These clouds are generally increasing in amount. They have a regular structure and pattern. Although they may be evaporating at the edges of the sheets and may have a roughly lenticular shape, they can be recognized by their increase in amount and thickness. This increase differentiates them from clouds $C_m=3$; and their greater amount, their increase, and their regularity distinguish them from $C_m=4$.
7. *$C_m=6$: altocumulus formed by a spreading out of the tops of cumulus.*—These sheets, shortly after their formation, are fairly thick and opaque. The clouds are large and fairly dark, with somewhat indistinct edges. Later these clouds become thinner and smaller, developing rifts between the elements, or at least semitransparent interstices. In classifying these clouds care must be taken not to confuse them with the fibrous, silky, whitish cirrus clouds that are formed at the tops of cumulonimbus clouds. They must, on the other hand, be distinguished from stratocumulus, $C_l=4$. The distinction in this case, of course, is the difference in size between the elements of altocumulus and stratocumulus.

8. *C_m=7: altocumulus associated with altostratus, or altostratus with a partially altocumulus character.*—Several cloud conditions can be classified as C_m=7:

(a) Typical altostratus cloud under which are altocumulus cloud sheets, definitely at a lower level.

(b) A more or less continuous layer of altocumulus clouds which has slightly beneath it a gray veil of cloud often hardly visible. This lower veil, for short times, hides the cloudlets sufficiently to produce the appearance of altostratus.

(c) Altocumulus growing thicker so that the individual cloudlets fuse together, and the sheet acquires the appearance of an altostratus sheet. C_m=7 also may indicate stratocumulus merging to form nimbostratus.

(d) Altostratus when dissipating and breaking up, taking on the appearance of altocumulus clouds.

(e) Opaque cloud sheets with more or less irregular, corrugated structure, too dense and too thick for the transparency of the ripples to afford any criterion for their classification.

9. *C_m=8: altocumulus castellatus, or scattered cumuliform tufts.*—The altocumulus castellatus appear as a series of small cumuliform masses with vertical development arranged in a line and resting on a common horizontal base. Cumuliform tufts appear white or gray, scattered in the sky, without definite shadow and without bases. The upper rounded parts are slightly domed.

10. *C_m=9: altocumulus in several sheets at different levels, generally associated with thick, fibrous veils of cloud and a chaotic appearance of the sky.*—The sky characterized as C_m=9 is complex, several different layers of altocumulus clouds being present. The cloud elements are poorly defined, having soft outlines. Bits of blue sky may be seen occasionally, due to the fact that no one layer of clouds covers the entire sky. The sky as a whole looks heavy, disordered, and stagnant.

(c) *State of the sky with respect to high clouds.—1. C_h=0: no high clouds visible.*—No high clouds may be visible, due

In groups, patches or layer with openings					Continuous layer or sheet		
Spreading or advancing over the sky		With cumuliform tufts	Stable or evaporating		Lowering or thickening		Degenerating
					Thin	Thick	Thick
Derived from cumulus	In parallel bands or ordered layer	(Castellatus)	Lenticular	In single layer	(Typical thin altostratus)	No definite relief on under surface	Altocumulus or altocumulus associated with altostratus, with definite relief on under surface
M_6	M_5	M_8	M_4	M_3	M_1	M_2	M_7

FIGURE 118.—State of the sky for middle clouds.
(Altocumulus in the typical chaotic, thundery type of sky is coded M_9.)

either to their absence or to their being hidden by lower clouds. In either case the high sky is classified as $C_h=0$.

2. *$C_h=1$: delicate cirrus, not increasing, scattered and isolated masses.*—These cirrus clouds are widely scattered in the sky. They do not collect into sheets or bands; they do not fuse together into masses of cirrostratus. Cirrus clouds whose strands end in an upturned hook must not be classified as $C_h=1$. They are $C_h=4$. $C_h=1$ is distinguished from $C_h=2$ by the sparseness of the clouds in $C_h=1$. Cirrus clouds classified as $C_h=1$ are more delicate than those of $C_h=3$ and, moreover, they do not originate from the tops of cumulonimbus. They do not increase in time and direction as do cirrus of $C_h=4$, $C_h=5$, and $C_h=6$. They do not form into sheets and bands as do cirrus of $C_h=5$ and $C_h=6$.

3. *$C_h=2$: delicate cirrus, not increasing; abundant, but not forming a continuous layer.*—$C_h=2$ differs from $C_h=1$ only in that cirrus of $C_h=2$ is more abundant than cirrus of

$C_h=1$. There is no tendency to increase in amount either in time or direction.

4. *$C_h=3$: cirrus of anvil clouds, usually dense.*—Cirrus of $C_h=3$ may be either still attached to the anvil of a cumulonimbus, or detached from the cumulonimbus which produced it, but still indicating its origin by its anvil shape or by its density and frayed-out appearance. It generally shows virga in places.

5. *$C_h=4$: cirrus, increasing generally in the form of hooks ending in a point or a small tuft.*—This type of cirrus increases both in amount and in a certain direction. In the direction in which the amount of these clouds increases, they tend to fuse together, but do not tend to become cirrostratus. These clouds differ from those of $C_h=5$ or $C_h=6$ in that the latter two types tend to fuse together into cirrostratus.

6. *$C_h=6$: cirrus (often in polar bands) or cirrostratus, advancing over the sky, but not more than 45° above the horizon.*—This is typically a sheet of fibrous cirrus partly uniting into cirrostratus, especially toward the horizon in the direction where the cirrus strands tend to fuse together. The cirrus is often in a herringbone formation, or is in great bands converging more or less to a point on the horizon. In this class is included also a sheet of cirrostratus without any cirrus. In either case the front of the cirrostratus sheet is not more than 45° above the horizon.

7. *$C_h=6$: cirrus (often in polar bands) or cirrostratus advancing over the sky, and more than 45° above the horizon.*—These clouds are the same as those of $C_h=5$, except that here the forward edge of the cirrostratus is more than 45° above the horizon.

8. *$C_h=7$: veil of cirrostratus covering the whole sky.*—Cirrostratus of $C_h=7$ appears in either of two cases. They are:

   (a) A thin, very uniform, nebulous veil some times hardly visible, sometimes relatively dense, always without definite detail, but always producing halo phenomena (halo, sun pillar) around the sun or moon.

   (b) A white fibrous sheet with more or less clearly defined fibers, often like a sheet of fibrous cirrus.

9. *$C_h=8$: cirrostratus not increasing and not covering the whole sky.*—This is a case of a veil or sheet of cirrostratus reaching the horizon in one direction, but leaving a segment of blue sky in the other direction. This segment of blue sky does not grow smaller. Generally the edge of this sheet is clear-cut, aud does not tail off into scattered cirrus. If the segment of blue sky is decreasing in size, the clouds would better be represented by $C_h=5$ or $C_h=6$.

10. *$C_h=9$: cirrocumulus predominating, associated with a small quantity of cirrus.*—The cirrocumulus must predominate for $C_h=9$ to be the correct classification. A cirrocumulus appearance on the edge of a cirrostratus layer is insufficient to identify the sky as $C_h=9$.

Detached or in groups or patches					Layer or sheet covering all or a part of the sky				
Increasing		Stable or decreasing			Increasing			Stable	
		Delicate		Dense	Below 45°	Above 45°			
Delicate, usually with hooks or tufts	More or less dense probably derived from anvil	Scarce	Abundant	Probably derived from anvil	Sheet of cirrostratus or of fibrous cirrus merging into cirrostratus	Not covering whole sky	Has recently extended over whole sky	Covering whole sky	Covering almost but not quite whole sky
H_4	H_3	H_1	H_2	H_3	H_5	H_6	H_7	H_7	H_8

FIGURE 119.—State of the sky for upper clouds.
(If cirrocumulus predominates, use code H_9.)

29. Visibility.—*a. Definition.*—The visibility in any one direction is the greatest distance in that direction at which prominent objects such as mountains, buildings, and trees can be seen and identified by the normal eye, unaided by special optical devices such as binoculars,

telescopes, and glare-eliminating goggles. Eyeglasses that correct deficient eyes to normal may be used. *Visibility*, when used without reservation, refers to the average of the visibilities in all directions toward the horizon, provided that this average visibility prevails toward at least half of the horizon. If the average visibility is greater than the greatest visibility toward half of the horizon, the greatest value prevailing over half the horizon is the value used.

b. Recording visibility.—The visibility, being a distance, is recorded in miles and fractions of a mile. The following values may be recorded: 0, 1/8, 1/5, 1/4, 1/2, 3/4, 1, 1 1/4, 1 1/2, 1 3/4, 2, 2 1/4, 2 1/2, 3, 4, 5, etc., for whole numbers of miles. When the value of the visibility is actually between two of the recordable values, it is recorded at the value to which it is closest; when the actual visibility is halfway between two of these values, the lower value is recorded. One exception applies to the rule given above: whenever the actual visibility is less than 10 miles and more than 9 miles, it is recorded as 9. Whenever the visibility as defined above is fluctuating about some value less than 2 1/4 miles, by 1/4 of a mile or less on either side, this fact is indicated by the entry of a "V" immediately following the visibility value. This "V" represents a variable visibility. When the variation is greater than one-fourth mile in either direction, or the visibility is greater than 2 miles, the variation in visibility can be entered only as a remark, and must be so entered on Weather Service forms. When the visibility in any one direction is half or less, or double or more the average visibility, this must be noted under remarks thus: "Visibility N E 1."

c. Observation of visibility.—Visibility is observed by noting the distances of the farthest visible objects. A table or chart giving the direction and distance of each prominent landmark used in observing visibility should be at hand at each weather station.

(1) *Observation of visibility by daylight.*—During daylight hours the best visibility landmarks are dark colored objects visible against the sky near the horizon. Where there is a scarcity of landmarks, the visibility is estimated on the basis of the clarity of the farthest landmark visible.

(2) *Observation of visibility during the night.*—At night the visibility is observed by noting the distances of the farthest visible moderate lights. Airway beacons are hereby excluded from night-visibility markers. This does not exclude the course (red and green) lights from among visibility markers. The outlines of mountains are appropriate visibility markers. Where there is a scarcity of night markers, the clarity of the most distant visible lights is considered in

estimating the visibility. The brightness of stars near the horizon may also be used as a guide in estimating visibilities.

(3) *Observation of visibility in all directions.*—Visibility must be observed in all directions in order that the observation may be representative. If no one observation point affords a view in all directions, the observer must take the observation of visibility from several points so as to get the visibility in as many directions as possible.

d. Obstructions.—Whenever the visibility is 6 miles or less, this fact indicates that there is present some meteorological phenomenon which is reducing the visibility. Therefore, whenever the visibility is 6 miles or less, some weather phenomenon or obstruction to visibility must be recorded, indicating the cause of the visibility reduction. On the other hand, whenever the visibility is greater than 6 miles, this indicates that no obstruction to visibility is significant enough to be recorded.

30. Minimum temperature.—*a. Definition.*—The minimum temperature is the lowest temperature that occurs during a specified period. A properly exposed minimum thermometer ML–5 is used in observing the minimum temperature. The reading of the minimum thermometer, under proper conditions and after any necessary corrections have been made, is the lowest temperature that occurred between the time the instrument was last set and the time of the observation.

b. Observation of minimum temperature.—(1) The minimum thermometer is observed during the regularly scheduled observation at or nearest 8:00 a. m., local standard time. The observation is made while the instrument is in its rest position. The end of the index farthest from the bulb indicates the minimum-temperature reading. This reading is taken to the nearest tenth by estimating the number of tenths of a degree that the index extends beyond the next lower whole degree mark, and adding this number of tenths to the value of the next lower whole degree value.

(2) Some minimum thermometers are accompanied by correction cards. These cards indicate a correction to be applied to the thermometer reading at every 10°. The value of the correction for the observed temperature reading is determined by single interpolations to the nearest tenth of a degree, and this value is added algebraically to the observed reading. However, the correction is not applied if the temperature reading is greater than 42° *and* the correction is less than 0.3° plus or minus.

(3) After a regularly scheduled observation of minimum temperature is taken for record, the minimum thermometer is reset. To

reset a minimum thermometer it is turned to a vertical position with the bulb up, and held that way until the index reaches the end of the column of alcohol. The instrument is then returned to the horizontal operation position.

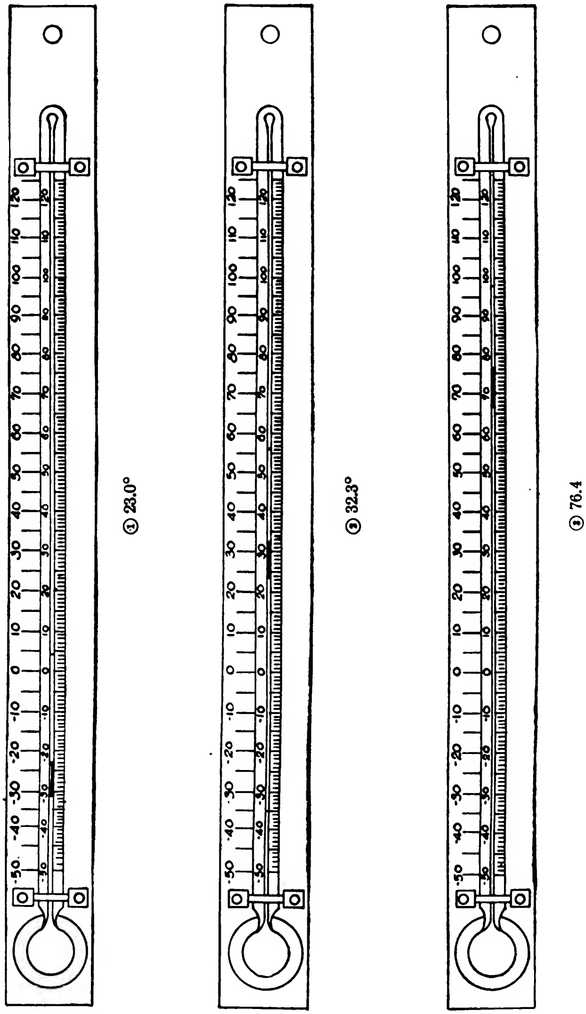


FIGURE 120.—Minimum temperature readings.

c. Precautions to be taken in observing minimum temperatures.—Care must be taken that the minimum thermometer is properly exposed and that the readings are unaffected by the presence of the observer. The instrument must be free from jarring, which may cause the index

to be displaced from its proper position. The accuracy of the observation should be checked further to insure that the minimum temperature is as low as, or lower than, any current air-temperature observation taken during the period to which the minimum temperature applies. The minimum temperature must be checked against the minimum reading of the thermograph. In reading the minimum thermometer care must be taken that the line of sight of the observer to the end of the index is perpendicular to the minimum thermometer.

31. Maximum temperature.—*a. Definition.*—The maximum temperature is the highest temperature that occurs during a specified period. A properly exposed maximum thermometer ML-4 is used in observing the maximum temperature. The reading of the maximum thermometer, under proper conditions and after any necessary corrections have been applied, is the highest temperature that occurred between the time that the instrument was last set and the time of the observation.

b. Observation of maximum temperature.—(1) The maximum temperature is observed during the regularly scheduled observation at or nearest 8:00 a. m., local standard time. In taking the maximum temperature observation the observer gently releases the maximum-thermometer locking pawl of the Townsend support, and permits the maximum thermometer slowly to attain a vertical position with the bulb lowest. This is the reading position. The maximum thermometer reading is taken from the top of the mercury column. This reading is taken to the nearest tenth of a degree by estimating the number of tenths of a degree that the mercury column extends beyond the next lower degree mark, and adding this number of tenths algebraically to the value of the next lower degree mark.

(2) When maximum thermometers are accompanied by correction cards, corrections are applied to them in the same manner as to minimum thermometers. The appropriate correction, obtained by interpolation, is added algebraically to the observed reading. Corrections are not applied when the maximum temperature is greater than 42° *and* the correction is less than plus or minus 0.3°.

(3) After the regularly scheduled observation of maximum temperature is taken, the maximum thermometer is reset. To reset the maximum thermometer, the observer spins it on the long projection stud of the Townsend support until the reading is the same as, or within two degrees of, the current temperature. The instrument is then locked in the horizontal position.

c. Precautions to be taken in observing maximum temperatures.—Care must be taken that the maximum thermometer is properly ex-

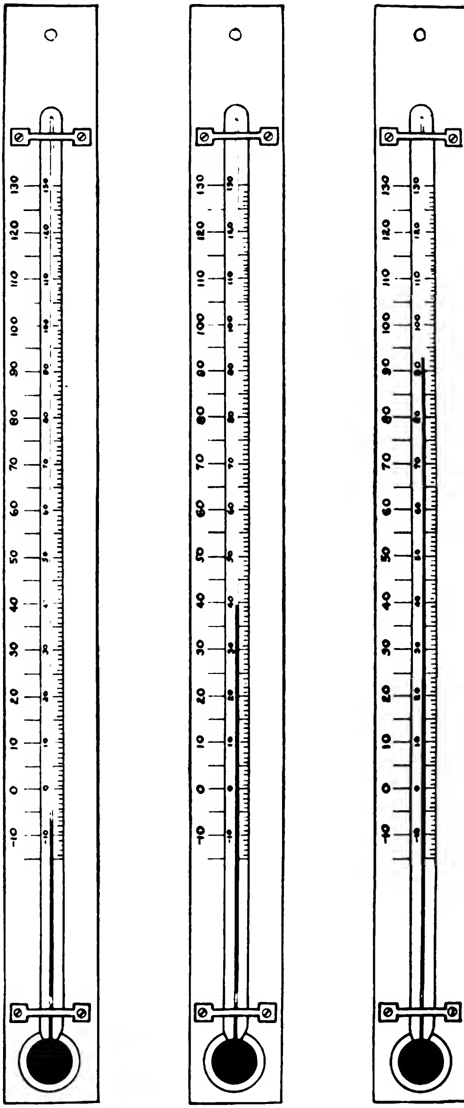


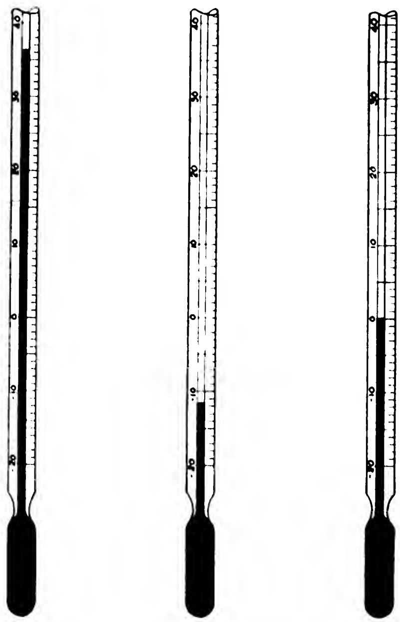
FIGURE 121.—Maximum temperature readings.

posed and that the readings are unaffected by the presence of the observer. The instrument must be insured against jarring and rapid motion prior to its being read. The maximum temperature must be as high as, or higher than, any temperature observed since it was last

set. The maximum temperature must be checked against the maximum indicated by the thermograph. In reading the thermometer, care should be taken by the observer that his line of sight to the top of the mercury column is perpendicular to the thermometer.

32. Temperature.—*a. Definition.*—When temperature is referred to without reservation, it indicates current air temperature. Temperature is observed with a simple dry-bulb thermometer, which is part of psychrometer ML-24.

b. Observation of temperature.—When no precipitation is falling, the temperature is observed simultaneously with the wet-bulb temperature.



① 36.3° ② 11.6° ③ 0.1°

FIGURE 122.—Temperature readings.

When precipitation is falling, the temperature is observed before the psychrometer is removed from the instrument shelter, in order that the thermometer may be dry when read. The thermometer is held in a vertical position while being read. The temperature is read to the nearest tenth of a degree in the same manner as is the maximum or minimum temperature. When correction cards accompany thermometers, the value of the correction is interpolated from the observed temperature reading, and this correction is added algebraically to the

observed temperature reading. The correction is not applied in case of a temperature greater than 42° and a correction less than 0.3°.

c. Precautions to be taken in observing temperature.—Care must be taken that the reading is not affected by contact of the observer with the thermometer, by the observer's breathing on the instrument, or by direct rays of the sun falling on the thermometer while it is being read. The instrument must be prevented from being wet.

33. Wet-bulb temperature.—*a. Definition.*—Wet-bulb temperature is the lowest temperature to which a thermometer can be reduced by evaporating water from it. Wet-bulb temperature is observed by means of the wet-bulb thermometer which, together with the dry-bulb thermometer, comprises psychrometer ML-24.

b. Observation of wet-bulb temperature.—When the temperature is greater than 25°, the bulb of the wet-bulb thermometer is wetted by dipping into clean water. It is then whirled until successive readings of the wet-bulb thermometer equal the lowest of several readings, indicating that these readings are the wet-bulb temperature. For reading, the wet-bulb thermometer must be held vertically, and the observer's line of sight to the top of the mercury column must be perpendicular to the thermometer. The reading is taken to the nearest tenth of a degree, and corrections, when appropriate, are applied in the same manner as for the dry-bulb thermometer. When the temperature is less than 25°, the wet bulb should be wetted between 5 and 15 minutes before the time of observation, to insure that the time taken to obtain a good wet-bulb reading does not cause the observation to be accomplished late.

c. Precautions to be taken in observing wet-bulb temperatures.—Care must be taken that the wet-bulb thermometer reading is not affected by contact of the thermometer with the observer, by the observer's breathing on the instrument, or by direct rays of the sun falling on the instrument while it is being read. The bulb must still be wet when the reading is taken.

34. Thermograph reading.—The thermograph reading for any given time is the value of the thermogram at that time. The thermograph reading is obtained to the nearest tenth of a degree by estimating the number of tenths of a degree that the thermogram is above the next lower whole degree line, and adding that number of tenths to the value of the whole degree line. The observer notes when observing the thermogram any discrepancy between the maximum- and minimum-temperature values and the maximum and minimum temperatures as indicated by the thermogram. The observer notes as

the thermograph reading the value indicated by the present position of the thermograph pen. If no direct observation of temperature has been taken 12 hours previous to the current observation, the temperature 12 hours previous to the current observation is noted from the corrected thermograph reading. This temperature is to be used in reducing the pressure to sea level.

35. Hygrograph reading.—The hygrograph furnishes a continuous record of relative humidity. The hydrograph is read to the nearest whole percent.

36. Amount of precipitation.—*a. Definition.*—The amount of precipitation for a given period is the depth of accumulation of water (snow or ice first being melted to water), if all the precipitation that fell during that period were to accumulate over a level surface. In the Weather Service, amount of precipitation is measured by means of the tipping-bucket rain gage ML-30, or the standard 8-inch rain gage ML-17. The depth cf precipitation is expressed in inches and hundredths of an inch.

b. Measurement of precipitation.—(1) When precipitation is in the form of rain, the observer, if measuring the precipitation by means of the tipping-bucket rain gage, drains the precipitation from the gage through the stopcock at the bottom of the gage into the measuring tube. He then measures the depth of water by inserting the measuring stick vertically into the tube. If measurement of the amount of rain is by means of the standard 8-inch rain gage, the measuring stick is inserted into the inner tube of the gage and the amount noted.

(2) When precipitation is in the form of hail or snow, the tipping-bucket rain gage cannot be used, and the standard 8-inch rain gage is used with the funnel top and inner tube removed. The precipitation accumulates in the overflow attachment, or case. This precipitation is melted when necessary by addition of a measured amount of water, and then the water in the overflow attachment (melted precipitation and added water) is poured into the inner tube. Here the depth is measured, the amount of added water subtracted from this measurement, and the remainder, the measured amount of precipitation, is noted in inches and hundredths of an inch. After the measurement has been made, the water is disposed of, and the rain gage is set ready for further operation.

37. Depth of snow.—The depth of snow is the depth, in inches and tenths of an inch, of snow on the ground. The depth is measured with the measuring stick. An ordinary ruler or yardstick may also be employed. The best ground over which to measure the depth of

snow is level ground, where the snow is least affected by human activity and not sheltered by natural means such as trees or bushes. It is advisable to take several readings of snow depth and to use the average of what are judged to be the most representative values.

38. Weather and obstructions to visibility.—*a. Definition.*—Weather includes local, violent meteorological disturbances and precipitation. Obstructions to visibility are meteorological phenomena other than precipitation which significantly reduce the visibility.

b. Observation of weather phenomena.—(1) *Tornado.*—The tornado is a most violent storm of very small radius. It is accompanied by a dark, funnel-shaped cloud which extends down from a cumulonimbus cloud to the ground or near to it. Tornadoes cause much destruction along their paths. When a tornado is observed, it is recorded and reported as "TORNADO." Its direction from the observer is noted immediately thereafter. Thus, if a tornado appears southwest of the station, it is reported as TORNADO SW. Report of a tornado takes precedence over reports of all other weather phenomena. "Tornado" is never abbreviated.

(2) *Thunderstorm.*—(*a*) A thunderstorm is a storm attended by thunder and lightning. A thunderstorm is considered to be in progress at the station if thunder is heard or if thunder has been heard during the preceding 15 minutes. There are two intensities of thunderstorms observed and reported: the "heavy thunderstorm", "T+," and the "thunderstorm", "T." The distinction between the two intensities of thunderstorms depends upon the observer. The descriptions below should be followed as closely as possible in making the distinction:

1. Thunderstorm.—Occasional or fairly frequent flashes of lightning occur within the cloud, from cloud to cloud, or from cloud to ground; weak to loud peals of thunder occur; rainfall, if any, is light or moderate and sometimes heavy; hail, if any, is light or moderate; wind occurring with the passage of the storm overhead does not exceed a velocity of 40 miles per hour; the temperature drop with passage of the storm is not very large.

2. Heavy thunderstorm.—Nearly incessant, sharp lightning occurs; loud peals of almost continuous thunder occur; heavy rain occurs; hail may be of any intensity; wind occurring in connection with passage of the storm overhead exceeds a velocity of 40 miles per hour; a rapid drop in temperature, as much as 20° F. in 5 minutes, occurs with the passage of the storm.

(*b*) A thunderstorm is indicated on records and reports as "T", and a heavy thunderstorm as "T+." These symbols do not necessarily indicate any precipitation. If precipitation is occurring, it must be recorded and reported independently. Further information might be any of the following: Direction of the thunderstorm from the station, direction of motion of the thunderstorm, intensity and frequency of lightning or thunder, appearance of clouds. Report of a thunderstorm for weather takes precedence over all other weather phenomena except tornadoes. The occurrence of lightning without thunder does not constitute a thunderstorm. The lightning may be reported under "Remarks."

(3) *Rain.*—(*a*) Rain is the falling from clouds of drops of water (in the liquid state) of which most are larger, or if not larger then much sparser, than the drops in drizzle; the diameter of most of the drops is greater than one-fiftieth inch; the drops fall in free air faster than 10 feet per second. There are three intensities of rain reported. They are light rain (R—), moderate rain (R), and heavy rain (R+). The distinction between light and moderate rain is given below:

1. Light rain.—The rate of fall is between a trace and 0.10 inch, inclusive, in an hour, or a maximum of 0.01 inch in 6 minutes.

2. Moderate rain.—The rate of fall is between 0.11 inch and 0.30 inch, inclusive, in an hour, or from more than 0.01 inch to 0.03 inch in 6 minutes.

(*b*) The criteria for intensity of rain given above are the basic criteria. However, sometimes a measurement of the rate of accumulation of precipitation is impracticable, and the intensity of rain must be determined visually. The criteria given below may be used as a guide in determining the intensity of rain:

1. Light rain.—Individual drops are easily identifiable; no spray, or at most, very little spray is observable over pavements, roofs, etc.; puddles accumulate very slowly; appreciable time, sometimes over 2 minutes is required for the rain to wet pavements, roofs, or other dry surfaces; sound on roofs ranges from slow pattering to gentle swishing; trickles or steady small streams appear from gutters and downspouts.

2. Moderate rain.—Individual drops are not clearly identifiable; spray is observable just above pavements, roofs, and other hard surfaces; puddles form fairly rapidly; downspouts on buildings run one-fifth to one-half full; sound on roofs ranges from swishing to gentle roar.

3. Heavy rain.—Rain seemingly falls in sheets; individual drops are not identifiable; heavy spray to a height of several inches is observed on roofs and pavements; downspouts on buildings run half-full to full or overflowing; puddles form rapidly; visibility is impaired; sound on roofs resembles the roll of drums or a distinct roar.

(4) *Rain showers.*—Rain showers are the falling of raindrops from clouds in sudden bursts, with rapid changes in intensity. The clouds are irregular in shape and thickness, with breaks often occurring between clouds. Rain showers are reported in any of three intensities: light rain showers (RW−), moderate rain showers (RW), and heavy rain showers (RW+). The intensity of a rain shower is determined in the same way as is the intensity of rain, the assumption being made that the shower will continue just as continuous rain would.

(5) *Freezing rain.*—Freezing rain is rain which instantly freezes to objects in the open that it strikes, thus forming a glaze. At the surface, run-off may occur as in the case of rain, if the rate of fall is rapid. Freezing rain is reported in one of three intensities. These intensities, light freezing rain (ZR−), moderate freezing rain (ZR), and heavy freezing rain (ZR+), are determined by the same criteria as are the intensities of rain.

(6) *Drizzle.*—(*a*) Drizzle is the falling from clouds of minute (diameter less than one-fiftieth inch), very numerous drops which seem to float in the air, and are seen to move with even a slight motion of the air. Drizzle is reported in one of three intensities: Light drizzle (L−), moderate drizzle (L), and heavy drizzle (L+). The criteria for determining the intensity of drizzle are given below:

1. Light drizzle.—The drizzle itself reduces the visibility so that the reported visibility is 1¼ miles or more.

2. Moderate drizzle.—The drizzle itself reduces the visibility so that the reported visibility is greater than ⅝ mile and less than 1¼ mile, i. e., ¾ mile or 1 mile.

3. Heavy drizzle.—The drizzle itself reduces the visibility so that the reported visibility is less than ⅝ mile, but more than 5/16 mile, i. e., ½ mile.

(*b*) If the visibility is reduced by an obstruction to visibility in addition to the drizzle, the intensity of that obstruction to visibility is determined as if it were the only cause for the reduction of visibility, and the intensity of the drizzle is estimated on the basis of its rate of accumulation. Whenever the visibility is reduced so as to be reported as less than 5/16 mile, i. e., as ¼, ⅕, ⅛ mile or zero, the reduction of visibility must be ascribed to some cause other than drizzle.

(7) *Freezing drizzle.*—Freezing drizzle is drizzle whose drops freeze instantly upon striking objects in the open, thereby forming a glaze over those objects. Freezing drizzle is reported in one of three intensities. These intensities are light freezing drizzle (ZL−), moderate freezing drizzle (ZL), and heavy freezing drizzle (ZL+). These intensities are determined by the same criteria as are the intensities of drizzle.

(8) *Snow.*—(*a*) Snow is the falling from clouds of ice crystals or groups of ice crystals, mainly in branched, hexagonal shapes. Snow may be reported in any one of three intensities: light snow (S−), moderate snow (S), and heavy snow (S+). The criteria for determining the intensity of snow are given below:

1. *Light snow.*—The snow itself reduces the visibility so that the visibility reported is greater than ⅝ mile.
2. *Moderate snow.*—The snow itself reduces the visibility so that it is reported at less than ⅝ mile, but more than 5/16 mile, i. e., ½ mile.
3. *Heavy snow.*—The snow itself reduces the visibility so that it is reported as less than 5/16 mile, i. e., as ¼, ⅙, ⅛ mile or zero.

(*b*) If an obstruction to visibility is reducing it at the same time as is the snow, the intensity of that obstruction must be determined as if it alone were reducing the visibility. The intensity of the snow must be determined on the basis of its rate of accumulation, when it is occurring at the same time as an obstruction to visibility.

(9) *Snow showers.*—Snow showers are the falling of snowflakes from clouds in sudden bursts, with rapid changes in intensity. The clouds are irregular in shape and thickness, breaks often occurring between clouds. There are three reported intensities of snow showers: light snow showers (SW−), moderate snow showers (SW), and heavy snow showers (SW+). These intensities are determined by the same criteria as are the similar intensities of snow.

(10) *Snow pellets.*—Snow pellets are the falling from clouds of white, opaque, round (sometimes conical) grains of snowlike structure one-sixteenth to one-fourth inch in diameter. These grains are crisp and easily compressible; they rebound when they strike hard surfaces, often bursting. Snow pellets occur almost exclusively in showers. Snow pellets may be reported in any of three intensities: light snow pellets (SP−), moderate snow pellets (SP), and heavy snow pellets (SP+). These intensities are determined by the same criteria as determine the intensity of snow.

(11) *Sleet (ice pellets).*—(*a*) Sleet is the falling from clouds of precipitation which, when it reaches the ground, is composed of transparent, globular, hard grains of ice, ranging from one twenty-fifth to four twenty-fifths inch in size. These grains of ice rebound when they strike a hard surface. Sleet particles are formed by the freezing of raindrops as they fall through the air, before they strike the ground.

(*b*) Sleet is reported in any of three intensities: light sleet (E−), moderate sleet (E), and heavy sleet (E+). The various intensities are distinguished by their rates of fall and accumulation as given below:

1. Light sleet.—A few pellets fall.

2. Moderate sleet.—Pellets fall at a moderate rate; there is some accumulation on the ground.

3. Heavy sleet.—Pellets fall at a heavy rate; there is a rapid accumulation on the ground.

(12) *Hail.*—(*a*) Hail is the falling from clouds of ice balls or stones, or fused groups of ice balls, usually ranging from ⅕ inch to 2 inches in diameter, and sometimes larger. The hailstones are sometimes quite transparent and sometimes have the structure of clear ice shells alternating with shells of an opaque, snowlike composition. Hail occurs in violent or prolonged thunderstorms, and usually when the temperature at the ground is more than 32° F.

(*b*) Hail is reported in any of three intensities: light hail (A−), moderate hail (A), and heavy hail (A+). The intensities are distinguished on the following criteria:

1. Light hail.—Only a few balls or stones fall.

2. Moderate hail.—Hailstones fall at a moderate rate; there is some accumulation on the ground.

3. Heavy hail.—Hailstones fall in great numbers; the accumulation on the ground is rapid.

(13) *Small hail.*—(*a*) Small hail is the falling from clouds of semitransparent round or conical grains of frozen water, each generally consisting of a soft grain of hail as a nucleus, covered by a very thin ice layer which gives it a glazed appearance. The particles of small hail are not easily compressible nor crisp and thus do not burst nor rebound when they strike a hard surface. Due to their usual occurrence at temperatures above freezing, the particles are frequently wet.

(*b*) Small hail is reported in any of three intensities: light small hail (AP−), moderate small hail (AP), and heavy small hail (AP+). These intensities are distinguished on the basis of the criteria below:

1. Light small hail.—Only a few grains of small hail fall.

2. Moderate small hail.—Grains of small hail fall at a moderate rate; there is some accumulation on the ground.

3. Heavy small hail.—Grains of small hail fall in great numbers; the accumulation on the ground is rapid.

(14) *Rain squall.*—(*a*) A rain squall is a sudden storm of brief duration, during which rain showers occur, accompanied by an increase in the wind. Rain squalls are reported in any of three intensities: light rain squalls (RQ−), moderate rain squalls (RQ), and severe rain squalls (RQ+). These intensities are distinguished on the basis of the most intense gust of wind that occurs during the squall, thus:

1. Light rain squalls.—Gusts do not exceed a velocity of 24 miles per hour.

2. Moderate rain squalls.—Gusts at the maximum velocity are between 25 miles per hour and 39 miles per hour, inclusive.

3. Severe rain squalls.—Gusts at their maximum exceed a velocity of 39 miles per hour.

(*b*) Rain squalls are reported at a station if they are occurring at the time of observation, of if precipitation is still falling and the gusts occurred within the preceding 15 minutes, or if no precipitation is falling at the time of observation but intermittent precipitation fell just previous to the observation and a rain squall occurred within the preceding 15 minutes. When precipitation is falling at the time of observation and rain squalls are being reported, both the precipitation and the rain squalls are recorded and reported under "weather." Rain squalls are entered on forms and reported immediately following precipitation, if any, and before obstructions to visibility, if any.

(*15*) *Snow squall.*—A snow squall is a sudden storm of brief duration, during which snow showers occur accompanied by an increase in the wind. Snow squalls are reported in any of three intensities: light snow squalls (SQ−), moderate snow squalls (SQ), and severe snow squalls (SQ+). The distinction between the several intensities of snow squalls is the same as the distinction between the several intensities of rain squalls. The rules for reporting snow squalls are the same as for rain squalls.

(16) *Wind shifts.*—Wind shifts are reported immediately following the wind, and are described in paragraph 39.

(17) *Haze.*—Haze is an obstruction to visibility due to presence in the air of dust or salt particles so small that they are invisible, but so numerous as to reduce the visibility to 6 miles or less. In the presence of haze the sky acquires a hazy and opalescent appearance, and the landscape acquires an appearance of having a veil over it which sub-

dues its colors. Haze appears bluish when viewed with a dark background, such as a mountain, and of a dirty yellow or orange color when viewed with a bright background, such as the sun or clouds. There is but one intensity of haze (H). Haze very rarely reduces the visibility below 3 miles.

(18) *Smoke.*—(*a*) Smoke is an obstruction to visibility due to presence in the air of foreign matter resulting from combustion. Smoke is distinguished from other obstructions to visibility by its odor and by the red color the sun appears to have when seen through smoke. The color of the sun through smoke is deep red when the sun is near the horizon, and a light reddish tinge when the sun is above the horizon. Smoke from forest fires appears light grayish or bluish in color when viewed from a distance. Smoke in a city may appear black, gray, or brown.

(*b*) Smoke is reported in any of three intensities: light smoke (K−), moderate smoke (K), and thick smoke (K+). The intensity of smoke is determined by the following criteria:

1. *Light smoke.*—Smoke itself reduces the visibility to such an extent that the visibility is reported as 1¼ miles or more.

2. *Moderate smoke.*—Smoke itself reduces the visibility to such an extent that the visibility is reported as less than 1¼ miles, but more than ⅝ mile, i. e., 1 or ¾ mile.

3. *Thick smoke.*—Smoke itself reduces the visibility to such an extent that the visibility is reported as less than ⅝ mile, i. e., as ½, ¼, ⅕, ⅛, or 0 mile.

(19) *Dust.*—(*a*) Dust is an obstruction to visibility due to presence in the air of foreign matter, fairly uniformly distributed, and consisting essentially of finely divided earth. The dust particles are not picked up locally. The presence of dust in the air causes distant objects to have a tannish or grayish hue. The sun is pale and colorless or sometimes has a yellow tinge when viewed through dust.

(*b*) Any of three intensities of dust may be reported: light dust (D−), moderate dust (D), or thick dust (D+). The intensities of dust are distinguished according to the following criteria:

1. *Light dust.*—The dust itself reduces the visibility to such an extent that the visibility is reported as 1¼ miles or more.

2. *Moderate dust.*—The dust itself reduces the visibility to such an extent that the visibility is reported as less than 1¼ miles but more than ⅝ mile, i. e., as 1 or ¾ mile.

3. *Thick dust.*—The dust itself reduces the visibility to such an extent that the visibility is reported as less than ⅝ mile, i. e., as ½, ¼, ⅕, ⅛, or 0 mile.

(20) *Blowing dust.*—Blowing dust is the obstruction of visibility by dust particles picked up locally by the wind and blown about in clouds or sheets. There are three intensities of blowing dust: light blowing dust (BD—), moderate blowing dust (BD), and thick blowing dust (BD+). These intensities are determined by the same criteria as are light dust, moderate dust, and thick dust, respectively. Thick blowing dust constitutes a dust storm.

(21) *Blowing sand.*—Blowing sand is the obstruction to visibility due to presence of sand particles in the air. The sand is picked up by the wind and blown about in clouds or sheets. The criteria for distinguishing the three intensities of blowing sand, light blowing sand (BN—), moderate blowing sand (BN), and thick blowing sand (BN+), are the same as the criteria for distinguishing light dust, moderate dust, and thick dust, respectively. Thick blowing sand constitutes a sand storm.

(22) *Blowing snow.*—(*a*) Blowing snow is the obstruction to visibility due to presence of snow particles in the air, which have been picked up by the wind and blown about in clouds and sheets. Blowing snow reduces the vertical visibility as well as the horizontal visibility. It is important that blowing snow be distinguished from snow and from drifting snow.

(*b*) Blowing snow is reported in any of three intensities: light blowing snow (BS—), moderate blowing snow (BS), and thick blowing snow (BS+). The criteria for determining the intensities of blowing snow are similar to those for snow intensities. They are:

1. *Light blowing snow.*—The blowing snow itself reduces the visibility to such an extent that the visibility is reported as 1¼ miles or more.
2. *Moderate blowing snow.*—The blowing snow itself reduces the visibility to such an extent that the visibility is reported as more than ⅝ mile but less than 1¼ miles.
3. *Thick blowing snow.*—The blowing snow itself reduces the visibility to such an extent that the visibility is reported as less than ⅝ mile.

(23) *Drifting snow.*—Drifting snow is the obstruction to visibility due to presence in the air of snow particles picked up by the wind and carried by the wind fairly close to the ground. Drifting snow does not appreciably reduce the vertical visibility. Drifting snow may be reported in any of three intensities: light drifting snow (GS—), moderate drifting snow (GS), and thick drifting snow (GS+). The distinction of these intensities is based on the horizontal visibilities,

and corresponds to the ranges of visibilities reported for light blowing snow, moderate blowing snow, and thick blowing snow, respectively.

(24) *Damp haze.*—Damp haze is the obstruction to visibility due to presence in the air of very small water droplets or very hygroscopic particles. This obstruction to visibility very rarely reduces the visibility as low as 1¼ miles. Damp haze differs from fog in that the droplets of water are fewer and smaller and can occur at relative humidities lower than those at which fog occurs. Damp haze differs from haze in appearance by its grayish color. Clouds viewed through damp haze have a greasy appearance, as though seen through a dirty window. Damp haze is usually accompanied by higher relative humidities than is haze. Damp haze, forming exclusively in oceanic regions, may be observed in such regions or in nearby areas to which the condition may have been transported by the wind. Damp haze has but one intensity, and is represented by F — —.

(25) *Fog.*—(*a*) Fog is the obstruction to visibility due to presence of minute water droplets formed by condensation. Fog is essentially the same as cloud except that fog occurs at the ground.

(*b*) Fog is reported in any of four intensities: light fog (F—), moderate fog (F), thick fog (F+), and dense fog (FF). The criteria for the distinction of the several intensities of fog follow:

1. Light fog.—The fog itself reduces the visibility to such an extent that the visibility is reported as not less than ⅝ mile.

2. Moderate fog.—The fog itself reduces the visibility to such an extent that the visibility is reported as less than ⅝ mile, but not less than 5/16 mile, i. e., the visibility is reported as ½ mile.

3. Thick fog.—The fog itself reduces the visibility to such an extent that the visibility is reported as less than 5/16 mile, but not less than ⅛ mile, i. e., the visibility is reported as ¼ or ⅛ mile.

4. Dense fog.—The fog itself reduces the visibility to such an extent that the visibility is reported as less than ⅛ mile, i. e., as ⅛ mile or 0.

(*26*) *Ground fog.*—Ground fog is the obstruction to visibility due to presence of minute water droplets as in fog, except that in ground fog the obstruction to visibility exists close to the ground only. The vertical visibility is thus unobstructed and sky conditions can be observed. Ground fog is reported in any of four intensities: light ground fog (GF—), moderate ground fog (GF), thick ground fog

(GF+), and dense ground fog (GFF). These intensities are distinguished on the basis of horizontal visibility, the same ranges of visibilities applying as for light fog, moderate fog, thick fog, and dense fog, respectively.

(27) *Ice fog.*—Ice fog is the obstruction to visibility due to presence of ice crystals or spicules in the air. These ice particles are formed by sublimation of the water vapor in the air and constitute an ice cloud at the ground. Ice fog is reported in any of four intensities: light ice fog (IF—), moderate ice fog (IF), thick ice fog (IF+), and dense ice fog (IFF). These intensities of ice fog are distinguished according to the same criteria as are light fog, moderate fog, thick fog, and dense fog.

c. Occurrence of several weather phenomena and/or obstructions to visibility simultaneously.—When several weather phenomena and/or obstructions to visibility are observed at one observation, they are to be entered under weather and/or obstructions to visibility in the order prescribed by the following rules:

(1) Weather phenomena are entered on forms and/or reported before obstructions to visibility.

(2) When a tornado occurs, it is entered or reported with precedence over all other weather phenomena.

(3) When a thunderstorm is entered or reported, it takes precedence over any other weather phenomenon except a tornado.

(4) A squall is reported after any other weather phenomenon present and before any obstructions to visibility.

(5) When several types of precipitation are falling concurrently, that type of precipitation which is estimated as accounting for the greatest amount of precipitation at the time of the observation is noted first; that type of precipitation that is estimated as accounting for the second greatest amount of precipitation at the time of observation is noted second, etc.

(6) When several obstructions to visibility are present, they are noted in the order of their intensity. That obstruction which is estimated as being predominant is assigned such an intensity (light, moderate, thick, dense) as would reduce the visibility to the observed value even if the other obstructions were not present. The other obstruction intensities are obtained by direct estimation. When precipitation and obstruction to visibility are reported concurrently, the obstruction to visibility is assigned such an intensity as would reduce the visibility to the observed value even if the precipitation were not present, and the precipitation intensity is determined on the basis of the rate of accumulation.

d. Beginnings and endings of weather and obstructions to visibility.—Whenever a tornado, a thunderstorm, a squall, any type of precipitation, or any obstruction to visibility begins, ends, or changes in intensity, this beginning or ending or change must be indicated with its time of occurrence on the proper forms. However, if the phenomenon occurs intermittently and the period between one ending and the next beginning is less than 20 minutes, the phenomenon may be characterized as intermittent, and the intervals (less than 20 minutes in duration) between its occurrences need not be recorded, if no recorded observation is taken during the interval. If an observation is recorded between successive occurrences of an intermittent phenomenon, the weather and obstructions to visibility actually present at that time are recorded, also the latest ending of intermittent precipitation and the next beginning, if any. Intermittent phenomena may be carried in the remarks, if appropriate. When several forms of precipitation are occurring simultaneously, the combination of the several forms is considered as the type of precipitation present. When one of the phenomena begins, ends, or changes in intensity, the combination previously present is ended and the new combination is indicated as beginning at that time. Changes in combinations of obstructions to visibility are noted in the same manner.

e. Abbreviations to be used in recording weather phenomena and obstructions to visibility.—Tornado is never abbreviated. The following abbreviations shall be used on all forms in the Weather Service:

T, T+	Thunderstorm; heavy thunderstorm.
R−, R, R+	Light rain; moderate rain; heavy rain.
RW−, RW, RW+	Light rain showers; moderate rain showers; heavy rain showers.
ZR−, ZR, ZR+	Light freezing rain; moderate freezing rain; heavy freezing rain.
L−, L, L+	Light drizzle; moderate drizzle; heavy drizzle.
ZL−, ZL, ZL+	Light freezing drizzle; moderate freezing drizzle; heavy freezing drizzle.
S−, S, S+	Light snow; moderate snow; heavy snow.
SW−, SW, SW+	Light snow showers; moderate snow showers; heavy snow showers.
SP−, SP, SP+	Light snow pellets; moderate snow pellets; heavy snow pellets.
E−, E, E+	Light sleet; moderate sleet; heavy sleet.
A−, A, A+	Light hail; moderate hail; heavy hail.
AP−, AP, AP+	Light small hail; moderate small hail; heavy small hail.
RQ−, RQ, RQ+	Light rain squall; moderate rain squall; severe rain squall.
SQ−, SQ, SQ+	Light snow squall; moderate snow squall; heavy snow squall.

H	Haze.
K−, K, K+	Light smoke; moderate smoke; thick smoke.
D−, D, D+	Light dust; moderate dust; thick dust.
BD−, BD, BD+	Light blowing dust; moderate blowing dust; thick blowing dust.
BN−, BN, BN+	Light blowing sand; moderate blowing sand; thick blowing sand.
BS−, BS, BS+	Light blowing snow; moderate blowing snow; thick blowing snow.
F − −	Damp haze.
F−, F, F+, FF	Light fog; moderate fog; thick fog; dense fog.
GF−, GF, GF+, GFF	Light ground fog; moderate ground fog; thick ground fog; dense ground fog.
IF−, IF, IF+, IFF	Light ice fog; moderate ice fog; thick ice fog; dense ice fog.

NOTE.—The abbrevations given above for sleet (E), snow showers (SW), snow (S), are not to be used in remarks. In remarks, "slt" will be used for sleet, "snw" will be used for snow, and "snw shwrs" will be used for snow showers.

39. Wind.—*a. Wind direction and velocity.*—(1) The direction and velocity of the wind are noted in the surface-weather observation. The direction is expressed as the nearest of the 16 points of the compass to that from which the wind is blowing. The velocity is given in miles per hour.

(2) The data for the wind observation are taken from indicator ML-117 or other wind-indicating equipment inside the weather station. However, before the observer completes his outdoor observation, he must check to see that the wind vane and the anemometer are in proper condition. The wind vane must point into the wind, and unless there is a calm, the anemometer cups must be rotating. If the wind vane is out of order, the observer observes the wind direction from the movement of smoke, dust, etc. If the anemometer is not functioning properly, the wind velocity is estimated. The following table is given as a guide for the estimation of wind velocities:

Velocity (miles per hour)	Specifications for estimating velocities
Less than 1	Smoke rises vertically.
1 to 3	Direction of wind shown by smoke drift but not by wind vanes.
4 to 7	Wind felt on face; leaves rustle; ordinary vane moved by wind.
8 to 12	Leaves and small twigs in constant motion; wind extends light flag.
13 to 18	Raises dust and loose paper; small branches are moved.

Velocity (miles per hour)	Specifications for measuring velocities
19 to 24	Small trees in leaf begin sway; crested wavelets form on inland waters.
25 to 31	Large branches in motion; whistling heard in telegraph wires umbrellas used with difficulty.
32 to 38	Whole trees in motion; inconvenience felt in walking against the wind.
39 to 46	Breaks twigs off trees; generally impedes progress.
47 to 54	Slight structural damage occurs (chimney pots and slate removed).
55 to 63	Trees uprooted; considerable structural damage occurs.
64 to 75	Rarely experienced; accompanied by widespread damage.
Above 75.	

(3) When the wind velocity is estimated, this fact is indicated by an "E" immediately following the velocity, without space. Thus "NNW15E" would indicate a wind from the north-northwest with an estimated velocity of 15 miles per hour.

(4) If the anemometer cups are not turning and there is no wind noticeable, the wind will be recorded as calm, indicated by the entry of a "C."

(5) If the anemometer cups are rotating and the instruments appear to be functioning properly, the direction and velocity of the wind are taken from the indicators inside the station. The velocity reported should be the average occurring during a minute of the observation.

b. Gustiness.—(1) A gust is a rapid change of wind velocity wherein the velocity changes 10 miles per hour or more, in less than 15 seconds. Fresh gusts are gusts wherein the velocity changes 10 miles per hour or more, in less than 15 seconds, and wherein the maximum velocity reached is less than 25 miles per hour. Strong gusts are gusts wherein the velocity changes 10 miles per hour or more, in less than 15 seconds, and wherein the maximum velocity is 25 miles per hour or greater.

(2) Fresh gusts are indicated by a "—" symbol immediately following the wind velocity; strong gusts are indicated by a "+" symbol immediately following the wind velocity. Thus "WSW 22+" would indicate a wind from the west-southwest at a velocity of 22 miles per hour with strong gusts (reaching at least 25 miles per hour). "NW 14E—" would indicate a northwest wind with an estimated velocity of 14 miles per hour, with light gusts (less than 25 miles per hour).

c. Wind shifts.—(1) A wind shift is a rapid change of wind direction. Wind shifts usually are accompanied by gustiness and may be accom-

panied by rapid changes of wind velocity, temperature, cloudiness, weather and/or obstructions to visibility.

(2) Wind shifts are classified by intensity as mild, moderate, or severe according to the maximum velocities of the gusts occurring at the time of the wind shift. Different limiting values are used depending on whether or not the wind shift is accompanied by precipitation and/or a lowering of the ceiling.

(*a*) *If precipitation and/or a lowering of the ceiling* occurs at the time of the wind shift, the following specifications for determining the intensity of the wind shift apply:

1. *Mild.*—The maximum velocity of the wind gusts accompanying the shift is less than 25 miles per hour.

2. *Moderate.*—The maximum velocity of the wind gusts accompanying the shift is 25 miles per hour or greater, but less than 40 miles per hour.

3. *Severe.*—The maximum velocity of the wind gust accompanying the shift is 40 miles per hour or greater.

(*b*) *If neither precipitation nor lowering of the ceiling* accompanies the wind shift, the following specifications apply:

1. *Mild.*—The maximum velocity of the wind gusts accompanying the shift is less than 35 miles per hour.

2. *Moderate.*—The maximum velocity of the wind gusts accompanying the shift is 35 miles per hour or greater, but less than 50 miles per hour.

3. *Severe.*—The maximum velocity of the wind gusts accompanying the shift is 50 miles per hour or greater.

(3) The intensity of a wind shift is indicated as follows: "—" symbol indicates a mild wind shift; absence of an intensity symbol indicates moderate wind shift; "+" symbol indicates a severe wind shift.

(4) In recording or reporting a shift of wind, the following information must be noted: The wind direction previous to the wind shift; the time of the wind shift, and the standard of time used; the intensity of the wind shift (a moderate shift being indicated by the absence of an intensity symbol). Thus, a windshift occurring in the central standard time zone at 2:45 p. m., with the wind shifting from SSE. to W., accompanied by lowering of the ceiling and maximum winds of 52 miles per hour, would be noted in remarks on Form No. 2 as "SSE 1445C+".

40. Temperature of barometer.—The temperature of the barometer is obtained by reading the thermometer attached to the barom-

eter. This reading is ordinarily referred to as the "attached thermometer reading." The reading is always taken to the nearest half degree. When Form No. 79, "Barometric Corrections," indicates a correction of 0.5 or more for the attached thermometer at the observed temperature, that correction is added algebraically to the value indicated by the attached thermometer, and the result is recorded as the attached thermometer reading.

41. Observed barometer reading.—The observed barometer reading is obtained by gently tapping the cistern of the barometer; adjusting the level of the mercury in the cistern so that the mercury just barely touches the ivory point; adjusting the vernier so that its lower edge coincides with the top of the meniscus of the mercury column; and reading the height of the mercury column to the nearest one-thousandth of an inch by means of the vernier.

42. Barograph reading.—The barograph reading is the value of station pressure as indicated by the barograph at the time of observation. The barograph is read to the nearest hundredth of an inch. The barograph reading may be used to check the station pressure value computed from the barometer reading against gross errors. The barograph reading and the station pressure should agree easily.

43. Pressure tendency and change.—The pressure tendency and change during the 3 hours preceding the observation are obtained by inspection of the barograph trace.

a. Pressure tendency.—(1) The pressure tendency is the slope and change of slope of the barogram. It is represented by one of 10 symbols or by corresponding code number. The 10 types of tendencies are given below:

Code No.

(0) Pressure now higher than or equal to pressure 3 hours ago. Pressure rising, then falling.

(1) Pressure now higher than or equal to pressure 3 hours ago. Pressure rising, then steady; or pressure rising, then rising more slowly.

(2) Pressure now higher than or equal to pressure 3 hours ago. Pressure unsteady.

(3) Pressure now higher than or equal to pressure 3 hours ago. Pressure steadily rising, or steady.

(4) Pressure now higher than or equal to pressure 3 hours ago. Pressure falling, then rising; or pressure steady, then rising; or pressure rising, then rising more rapidly.

(5) Pressure now lower than pressure 3 hours ago. Pressure falling, then rising.

(6) Pressure now lower than pressure 3 hours ago. Pressure falling, then steady; or pressure falling, then falling less rapidly.

(7) Pressure now lower than pressure 3 hours ago. Pressure unsteady.

Code No.

(8) Pressure now lower than pressure 3 hours ago. Pressure falling steadily.

(9) Pressure now lower than pressure 3 hours ago. Pressure rising, then falling; or pressure steady, then falling; or pressure falling, then falling more rapidly.

(2) For a trace to be classified as unsteady (Code Nos. (7) or (2)) it must have at least two troughs or two crests, each one so pronounced as to have points on it which are more than 0.02 inch of pressure different from the value at the mean trace. When a barograph trace has more than one change of slope but does not have the above characteristics of an "unsteady" trace, it will be characterized so as to indicate whether there has been a net increase, or no change,

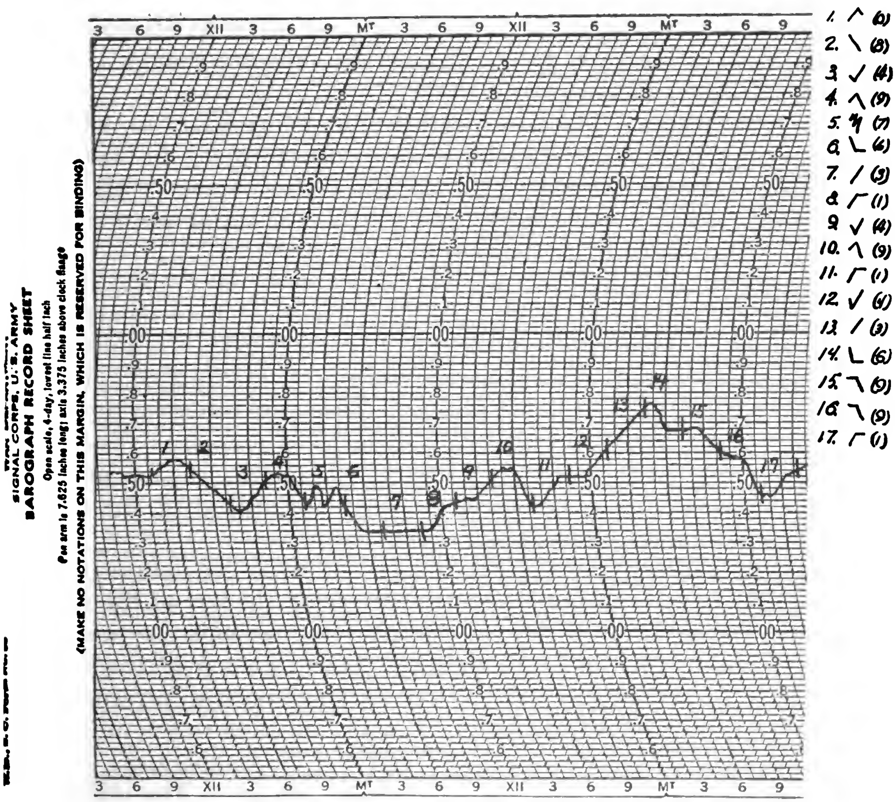


FIGURE 123.—Pressure reading from microbarogram.

or decrease of pressure in the preceding 3 hours, and whether the latter part of the trace shows an increase or decrease of pressure.

(3) Where there is a slight change in slope of the trace of the barograph, it will be considered a discontinuity if the change in direction of the trace is 22½° or greater (one-fourth of a right angle). If the change in direction is less than 22½°, that portion of the trace will be considered as steady. This rule is used to distinguish between numbers (3) and (2) or (4), and between (8) and (6) or (9). Where the barograph is used, a change in direction of 15° (one-sixth of a right angle) or more is necessary to constitute a discontinuity of slope.

b. Amount of pressure change.—The amount of pressure change is the difference between the pressure at the time of the observation and the pressure 3 hours earlier. This amount may be taken from the barograph trace and is observed to the nearest five-thousandths of an inch. The sense or the sign of the pressure change is given by the tendency characteristic.

44. Dew point.—The dew point is that temperature to which a volume of water vapor (usually mixed with air) must be cooled at constant pressure to cause saturation of the volume with water vapor. (Further cooling would cause condensation of water.) The dew point is expressed to the nearest whole degree.

a. Psychrometric tables.—(1) The dew point is obtained from psychrometric tables if the air temperature and wet-bulb temperature are known. The tables used in the Weather Service are those prepared for the United States Weather Bureau (W. B. No. 235). Different tables apply at different pressures, and there are tables for pressures of 30.00, 29.00, 27.00, 25.00, and 23.00 inches of pressure. The table corresponding to the pressure closest to the normal station pressure at the station is used at all observations regardless of the actual pressure at the time of the observation.

(2) Psychrometric tables are constructed with the value of the air temperature as the horizontal argument (along the left of the table), and the difference between the air temperature and the wet-bulb temperature as the vertical argument (along the top of the table). In the body of the table are the dew-point temperatures corresponding to the temperature shown on the left of the line, and to the difference between the wet-bulb temperature and the air temperature at the head of the column in which the dew point appears. The difference between the air temperature and the wet-bulb temperature is commonly referred to as the depression of the wet-bulb temperature.

b. Determination of the dew point. (1) *Method.*—The dew point is determined by:

(*a*) Determining the depression of the wet-bulb temperature.

(*b*) Finding the air temperature and depression of the wet-bulb temperature on the appropriate table, or the adjacent values thereto when the temperature and/or depression of the wet-bulb temperature do not appear in the arguments of the tables.

(*c*) Taking the value of the dew point to the nearest tenth from the table, using interpolation if necessary.

(*d*) Reducing the dew point to the nearest whole degree. The principles of interpolation for dew points is the same as for sea-level pressures.

(2) *Examples.*—In the following examples the readings were taken at Chanute Field where the psychrometric tables computed at 29.00 inches are used. Part of these tables is shown here in table II.

TABLE II.—*For computation of dew point*

[Pressure = 29.0 inches]

Air temp. t (°F)	Vapor press. e	Depression of wet-bulb thermometer $(t-t')$															
		0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0
20	0.103	18	17	15	13	11	8	5	2	−1	−5	−11	−18	−30			
21	.108	19	18	16	14	12	10	7	4	+1	−3	−8	−14	−23	−42		
22	.113	20	19	17	15	13	11	9	6	3	−1	−5	−10	−17	−29		
23	.118	22	20	18	16	14	12	10	8	5	+1	−3	−7	−13	−22	−40	
24	.124	23	21	19	18	16	14	11	9	6	3	±0	−4	−10	−17	−28	
25	.130	24	22	21	19	17	15	13	11	8	5	+2	−2	−6	−12	−21	−36
26	.136	25	23	22	20	18	16	14	12	10	7	4	±0	−4	−9	−15	−26
27	.143	26	24	23	21	20	18	16	14	12	9	6	+3	−1	−5	−11	−19
28	.150	27	25	24	22	21	19	17	15	13	11	8	5	+2	−2	−7	−14
29	.157	28	26	25	24	22	20	19	17	15	12	10	7	4	±0	−4	−9
30	.164	29	27	26	25	23	22	20	18	16	14	12	9	6	+3	−1	−5
31	.172	30	29	27	26	24	23	21	20	18	16	13	11	8	5	+2	−2
32	.180	31	30	28	27	26	24	23	21	19	17	15	13	10	8	4	+1
33	.187	32	31	29	28	27	25	24	22	21	19	17	15	12	10	7	3
34	.195	33	32	30	29	28	27	25	24	22	20	18	16	14	12	9	6
35	.203	34	33	31	30	29	28	26	25	23	22	20	18	16	14	11	8
36	.211	35	34	32	31	30	29	27	26	25	23	21	20	18	15	13	11
37	.219	36	35	33	32	31	30	28	27	26	24	23	21	19	17	15	13
38	.228	37	36	34	33	32	31	30	28	27	26	24	23	21	19	17	14
39	.237	38	37	36	34	33	32	31	29	28	27	25	24	22	21	19	16
40	.247	39	38	37	35	34	33	32	31	29	28	27	25	23	22	20	18
41	.256	40	39	38	37	35	34	33	32	30	29	28	26	25	23	22	20
42	.266	41	40	39	38	36	35	34	33	32	30	29	28	26	25	23	21
43	.277	42	41	40	39	38	36	35	34	33	31	30	29	27	26	24	23
44	287	43	42	41	40	39	38	36	35	34	32	31	30	29	27	26	24
45	.298	44	43	42	41	40	39	37	36	35	34	32	31	30	29	27	26
46	.310	45	44	43	42	41	40	39	37	36	35	34	32	31	30	28	27
47	.322	46	45	44	43	42	41	40	39	37	36	35	34	32	31	30	28
48	.334	47	46	45	44	43	42	41	40	39	37	36	35	34	32	31	30
49	.347	48	47	46	45	44	43	42	41	40	39	37	36	35	34	32	31
50	.360	49	48	47	46	45	44	43	42	41	40	39	37	36	35	34	32
51	.373	50	49	48	47	46	45	44	43	42	41	40	39	37	36	35	34
52	.387	51	50	49	48	47	46	45	44	43	42	41	40	39	37	36	35
53	.402	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	36
54	.417	53	52	51	50	49	49	48	47	46	44	43	42	41	40	39	38

TABLE II.—*For computation of dew point*—Continued

[Pressure=29.0 inches]

Air temp. t (°F)	Vapor press. e	Depression of wet-bulb thermometer ($t-t'$)															
		0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0
55	.432	54	53	52	52	51	50	49	48	47	46	45	43	42	41	40	39
56	.448	55	54	53	53	52	51	50	49	48	47	46	45	44	43	41	40
57	.465	56	55	54	54	53	52	51	50	49	48	47	46	45	44	43	42
58	.482	57	56	56	55	54	53	52	51	50	49	48	47	46	45	44	43
59	.499	58	57	57	56	55	54	53	52	51	50	49	48	47	46	45	44
60	.517	59	58	58	57	56	55	54	53	52	51	50	49	48	47	46	45
61	.536	60	59	59	58	57	56	55	54	53	52	52	51	50	49	48	46
62	.555	61	60	60	59	58	57	56	55	55	54	53	52	51	50	49	48
63	.575	62	61	61	60	59	58	57	56	56	55	54	53	52	51	50	49
64	.595	63	62	62	61	60	59	58	58	57	56	55	54	53	52	51	50
65	.616	64	63	63	62	61	60	59	59	58	57	56	55	54	53	52	51
66	.638	65	64	64	63	62	61	61	60	59	58	57	56	55	54	54	53
67	.661	66	65	65	64	63	62	62	61	60	59	58	57	56	56	55	54
68	.684	67	67	66	65	64	63	63	62	61	60	59	58	58	57	56	55
69	.707	68	68	67	66	65	64	64	63	62	61	60	60	59	58	57	56
70	.732	69	69	68	67	66	66	65	64	63	62	62	61	60	59	58	57
71	.757	70	70	69	68	67	67	66	65	64	63	63	62	61	60	59	58
72	.783	71	71	70	69	68	68	67	66	65	65	64	63	62	61	60	60
73	.810	72	72	71	70	69	69	68	67	66	66	65	64	63	62	62	61
74	.838	73	73	72	71	70	70	69	68	67	67	66	65	64	64	63	62
75	.866	74	74	73	72	71	71	70	69	68	68	67	66	65	65	64	63
76	.896	75	75	74	73	73	72	71	70	70	69	68	67	66	66	65	64
77	.926	76	76	75	74	74	73	72	71	71	70	69	68	68	67	66	65
78	.957	77	77	76	75	75	74	73	72	72	71	70	69	69	68	67	66
79	.989	78	78	77	76	76	75	74	73	73	72	71	70	70	69	68	67
80	1.022	79	79	78	77	77	76	75	75	74	73	72	72	71	70	69	69

(*a*) Both temperature and depression of wet-bulb temperature appear as arguments in the table.

Temperature: 45.0
Wet-bulb temperature: 40.5
***hence*—Depression of wet-bulb temp.: 4.5**

In table II (page 26, W. B. 235), the dew point on the line of temperature 45°, in the column headed 4.5°, is 35° (i. e., 35.0). The dew point is 35°.

(*b*) The temperature actually appears on the table as an argument, but depression of the wet-bulb temperature is a value intermediate between values appearing at the head of the table.

Temperature: 21.0
Wet-bulb temperature: 17.3
***hence*—Depression of wet-bulb temp.: 3.7**

The pertinent part of the table is:

	3.5	(3.7)	4.0
21.0	7		4

(Values inserted in parentheses are to facilitate interpolation.) The proportion set-up is:

$$\frac{3.7-3.5}{4.0-3.5}=\frac{x}{7-4} \text{ or } \frac{.2}{.5}=\frac{x}{3}$$

$$x=\frac{.6}{.5}=1.2$$

This value, $x=1.2$, must be subtracted from the 7 because the dew point decreases if depression of the wet-bulb temperature increases. The required dew point is $7-1.2=5.8$, or 6° to the nearest whole degree.

(*c*) Depression of the wet-bulb temperature actually appears on the table as an argument, but the temperature is an intermediate value.

Temperature: 53.3
Wet-bulb temperature: 49.8
hence—Depression of wet-bulb temp.: 3.5

The pertinent part of the table is:

	3. 5
53.0	46
(53.3)	
54.0	48

The interpolation is accomplished as follows:

$$\frac{53.3-53.0}{54.0-53.0}=\frac{x}{48.0-46.0} \text{ or } \frac{.3}{1.0}=\frac{x}{2.0}$$

$$x=.6$$

Since the dew point increases with increasing temperature, this value is added to the lower value of the dew point, giving $46.0+.6=46.6$, or 47° to the nearest whole degree.

(*d*) Neither temperature nor depression of the wet-bulb temperature appears as an argument in the table.

Temperature: 35.4
Wet-bulb temperature: 30.7
hence—Depression of wet-bulb temp.: 4.7

The pertinent part of the table is:

	4. 5	(4.7)	5. 0
35.0	23		22
(35.4)			
36.0	25		23

The first step here is to find the dew points appropriate to a temperature of 35.4

and depressions of the wet-bulb temperature of 4.5° and 5.0° respectively, by interpolation. For a depression of 4.5° the interpolation is carried out thus:

$$\frac{35.4-35.0}{36.0-35.0}=\frac{x}{25.0-23.0} \text{ or } \frac{4}{1.0}=\frac{x}{2.0}\ x=.8$$

Temperature, 35.4; depression of wet-bulb temp., 4.5; dew point, 23.8.

For a depression of 5.0° at temperature 35.4, the interpolation is as follows:

$$\frac{35.4-35.0}{36.0-35.0}=\frac{x}{23.0-22.0} \text{ or } \frac{.4}{1.0}=\frac{x}{1.0}\ x=.4$$

Temperature, 35.4; depression of wet-bulb temp., 5.0; dew point, 22.4. The extract from psychrometric tables may now be expanded thus:

	4. 5	(4. 7)	5. 0
35. 0	23		22
35. 4	23. 8		22. 4
36. 0	25		23

The desired dew point at temperature 35.4, and depression of wet-bulb temperature 4.7, is obtained by interpolation between 23.8 and 22.4, thus:

$$\frac{4.7-4.5}{5.0-4.5}=\frac{x}{23.8-22.4} \text{ or } \frac{.2}{.5}=\frac{x}{1.4}\ x=.56$$

The desired dew point is 23.8−.56=23.24, or 23°. Subtraction is used because the dew point increases as depression of the wet-bulb temperature increases.

(3) *Reduction.*—To reduce the dew point to the nearest whole degree when the decimal part is greater than .5, the next higher whole number is used; if the decimal part is less than .5, the decimal part is dropped, and the whole number remaining is the dew point to the nearest whole degree. When the decimal part is just .5, the value used is either the next higher whole number or the next lower whole number, depending on which is an even number, i. e., a multiple of 2. Thus, 39.4 would be reduced to 39; 44.7 would be reduced to 45; 37.5 would be reduced to 38; and −4.5 would be reduced to −4. This convention is used in dropping decimals in all instrumental and computed values of the weather observation.

45. Relative humidity.—The relative humidity is the ratio, expressed in percent, between the amount of water vapor actually present in the air and the maximum amount of water vapor that could be present at the temperature observed.

a. Psychrometric tables.—The relative humidity is obtained from the temperature and wet-bulb temperature with the use of psychrometric

tables. These psychrometric tables are contained in the tables prepared by the United States Weather Bureau (W. B. No. 235). Different tables, all included in W. B. No. 235 apply at different pressures. There are tables for pressures of 30.00, 29.00, 27.00, 25.00, and 23.00 inches of pressure. The table corresponding to the pressure closest to the normal station pressure at the station is used for all observations there, regardless of the actual pressure at the time. Reading of tables for relative humidity is similar to reading of tables for dew point, and interpolation is also the same for both tables.

b. Determination of the relative humidity.—(1) *Method.*—The relative humidity is determined by—

(*a*) Determining the depression of the wet-bulb temperature.

(*b*) Finding the air temperature and the depression of the wet-bulb temperature on the appropriate table.

(*c*) Obtaining the value of the relative humidity to the nearest tenth of 1 percent from the table, using interpolation if necessary.

(*d*) Reducing the relative humidity to the nearest whole percent.

TABLE III.—*For computation of relative humidity*

[Pressure = 29.0 inches]

Air temp. t (°F)	Depression of wet-bulb thermometer $(t-t')$																				
	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0	10.5
20	92	85	78	70	63	56	49	42	35	28	21	14	7								
21	93	86	78	71	64	57	50	44	37	30	24	17	10	3							
22	93	86	79	72	65	59	52	45	39	32	26	19	13	7	0						
23	93	87	80	73	66	60	53	47	41	34	28	22	16	10	3						
24	94	87	81	74	68	61	55	49	42	36	30	24	18	12	6	0					
25	94	87	81	75	69	63	56	50	44	38	32	27	21	15	9	4					
26	94	88	82	75	69	64	58	52	46	40	34	29	23	18	12	7	1				
27	94	88	82	76	70	65	59	53	48	42	36	31	26	20	15	9	4				
28	94	88	82	77	71	66	60	55	49	44	38	33	28	23	17	12	7	2			
29	94	89	83	78	72	67	61	56	51	45	40	35	30	25	20	15	10	5	0		
30	95	89	84	78	73	68	62	57	52	47	42	37	32	27	22	17	12	8	3		
31	95	89	84	79	74	69	63	58	53	49	44	39	34	29	24	20	15	10	6	1	
32	95	90	85	79	74	69	65	60	55	50	45	41	36	31	26	22	17	13	9	4	
33	95	90	85	80	76	71	66	61	56	52	47	42	38	33	29	24	20	16	11	7	3
34	95	90	86	81	77	72	67	62	58	53	49	44	40	35	31	27	22	18	14	9	5
35	95	91	86	82	77	73	68	64	59	55	50	46	41	37	33	29	24	20	16	12	8
36	95	91	87	82	78	73	69	65	61	56	52	48	43	39	35	31	27	23	18	14	10
37	95	91	87	83	79	74	70	66	62	58	54	49	45	41	37	33	29	25	21	17	13
38	96	91	87	83	79	75	71	67	63	59	55	51	47	43	39	35	31	27	23	19	15
39	96	92	88	84	80	76	72	68	64	60	56	52	48	44	41	37	33	29	25	21	17
40	96	92	88	84	80	76	72	68	64	61	57	53	49	46	42	38	35	31	27	23	20
41	96	92	88	84	80	77	73	69	65	62	58	54	50	47	43	40	36	33	29	26	22
42	96	92	88	85	81	77	73	70	66	62	59	55	51	48	45	41	38	34	31	28	24
43	96	92	88	85	81	78	74	70	67	63	60	56	52	49	46	43	39	36	32	29	26
44	96	93	89	85	82	78	74	71	68	64	61	57	54	51	47	44	40	37	34	31	28
45	96	93	89	86	82	79	75	71	68	65	61	58	55	52	48	45	42	39	36	33	29
46	96	93	89	86	82	79	75	72	69	65	62	59	56	53	49	46	43	40	37	34	31
47	96	93	89	86	83	79	76	73	69	66	63	60	57	54	50	47	44	41	38	35	32
48	96	93	90	87	83	80	76	73	70	67	63	60	57	54	51	48	45	42	39	36	34
49	96	93	90	87	83	80	77	74	71	67	64	61	58	55	52	49	46	43	40	37	35

TABLE III.—*For computation of relative humidity*—Continued

[Pressure = 29.0 inches]

Air temp. t (°F)	Depression of wet-bulb thermometer $(t-t')$																				
	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0	10.5
50	96	93	90	87	84	81	77	74	71	68	65	62	59	56	53	50	47	44	42	39	36
51	97	94	90	87	84	81	78	75	72	69	66	63	60	57	54	51	48	45	43	40	37
52	97	94	91	88	84	81	78	75	72	69	66	63	60	58	55	52	49	46	44	41	39
53	97	94	91	88	85	82	78	75	73	70	67	64	61	58	56	53	50	47	45	42	40
54	97	94	91	88	85	82	79	76	73	70	67	65	62	59	57	54	51	48	46	43	41
55	97	94	91	88	85	82	79	76	74	71	68	65	62	60	57	55	52	49	47	44	42
56	97	94	91	88	85	82	79	77	74	71	69	66	63	61	58	55	53	50	48	45	43
57	97	94	91	88	85	83	80	77	74	72	69	66	64	61	59	56	53	51	49	46	44
58	97	94	91	89	86	83	80	77	75	72	69	67	64	62	60	57	54	52	49	47	45
59	97	94	92	89	86	83	81	78	75	73	70	68	65	63	60	58	55	53	50	48	45
60	97	94	92	89	86	84	81	78	76	73	71	68	65	63	61	58	56	53	51	49	46
61	97	94	92	89	86	84	81	79	76	74	71	68	66	64	61	59	56	54	52	50	47
62	97	94	92	89	87	84	81	79	77	74	72	69	66	64	62	60	57	55	53	50	48
63	97	95	92	90	87	84	82	79	77	74	72	70	67	65	62	60	58	56	53	51	49
64	97	95	92	90	87	85	82	79	77	75	72	70	68	66	63	61	58	56	54	52	50
65	97	95	92	90	87	85	82	80	78	75	73	70	68	66	64	62	59	57	55	53	50
66	97	95	92	90	87	85	83	80	78	76	73	71	68	66	64	62	60	58	55	53	51
67	97	95	92	90	88	85	83	80	78	76	73	71	69	67	65	62	60	58	56	54	52
68	97	95	93	90	88	85	83	81	78	76	74	72	69	67	65	63	61	59	57	55	53
69	97	95	93	90	88	86	83	81	79	77	74	72	70	68	66	64	61	59	57	55	53
70	98	95	93	90	88	86	83	81	79	77	75	72	70	68	66	64	62	60	58	56	54
71	98	95	93	90	88	86	84	82	79	77	75	73	71	69	67	64	62	60	58	56	54
72	98	95	93	91	89	86	84	82	80	78	75	73	71	69	67	65	63	61	59	57	55
73	98	95	93	91	89	86	84	82	80	78	76	73	71	69	67	65	63	61	60	58	56
74	98	95	93	91	89	86	84	82	80	78	76	74	72	70	68	66	64	62	60	58	56
75	98	95	93	91	89	87	84	82	80	78	76	74	72	70	68	66	64	63	61	59	57
76	98	96	93	91	89	87	85	83	80	78	76	74	72	70	69	67	65	63	61	59	57
77	98	96	93	91	89	87	85	83	81	79	77	75	73	71	69	67	65	63	61	60	58
78	98	96	94	91	89	87	85	83	81	79	77	75	73	71	69	67	66	64	62	60	58
79	98	96	94	91	89	87	85	83	81	79	77	75	73	71	70	68	66	64	62	60	59
80	98	96	94	91	89	87	85	83	81	79	77	76	74	72	70	68	66	64	63	61	59

(2) *Examples.*—In the following examples the readings were taken at Chanute Field where the psychrometric tables for 29.00 inches are used. Several cases are presented which differ in interpolation.

(*a*) Both the temperature and depression of the wet-bulb temperature actually observed appear as arguments in the table.

Temperature: 45.0
Wet-bulb temperature: 40.5
hence—Depression of wet-bulb temp.: 4.5

On page 63 of the psychrometric tables, reproduced here as Table III, the relative humidity on the line for a temperature of 45°, in the column for a depression of the wet-bulb temperature of 4.5°, is 68.0%. The relative humidity is recorded as 68.

(*b*) The temperature actually appears in the table as an argument of the table, but the depression of the wet-bulb temperature is a value intermediate between values appearing at the head of the tables.

Temperature: 21.0
Wet-bulb temperature: 17.3
hence—Depression of wet-bulb temp.: 3.7

The pertinent part of the table is:

	3. 5	(3. 7)	4. 0
21.0	50. 0		44. 0

The following proportion is set up:

$$\frac{3.7-3.5}{4.0-3.5}=\frac{x}{50.0-44.0} \text{ or } \frac{.2}{.5}=\frac{x}{6}\ x=2.4$$

The relative humidity is 50.0−2.4=47.6 or 48 (to the nearest whole percent).

(*c*) The depression of the wet-bulb temperature actually appears at the head of the psychrometric tables, but the value of the temperature is intermediate between values of temperature appearing as arguments on the table.

Temperature: 53.3
Wet-bulb temperature: 49.8
hence—Depression of wet-bulb temp.: 3.5

The pertinent part of the table is:

	3. 5
53	78
(53.3)	
54	79

The following proportion is set up:

$$\frac{53.3-53.0}{54.0-53.0}=\frac{x}{79.0-78.0} \text{ or } \frac{.3}{1.0}=\frac{x}{1.0}\ x=.3$$

The relative humidity is 78.0 + .3=78.3, or 78 to the nearest whole percent.

(*d*) Neither the observed temperature nor depression of the wet-bulb temperature appears directly as an argument on the psychrometric tables.

Temperature: 35.4
Wet-bulb temperature: 30.7
hence—Depression of wet-bulb temp.: 4.7

The pertinent part of the table is:

	4.5	(4.7)	5.0
35.0	59		55
(35.4)			
36.0	61		56

The first step in this double interpolation is to determine the relative humidities appropriate to a temperature of 35.4 and depressions of the wet-bulb temperature

of 4.5 and 5.0, respectively, by interpolation. For the depression of the wet-bulb temperature of 4.5, the proportion set-up is:

$$\frac{35.4-35.0}{36.0-35.0}=\frac{x}{61.0-59.0} \text{ or } \frac{.4}{1.0}=\frac{x}{2.0}\; x=.8$$

The relative humidity at temperature 35.4 and depression of the wet-bulb temperature 4.5 is 59.8. For the relative humidity where the temperature is 35.4 and depression of the wet-bulb temperature is 5.0, the following proportion is set up:

$$\frac{35.4-35.0}{36.0-35.0}=\frac{x}{56.0-55.0} \text{ or } \frac{.4}{1.0}=\frac{x}{1.0}\; x=.4$$

The relative humidity at a temperature of 35.4, and a depression of the wet-bulb temperature of 5.0, is 55.4. When these values are inserted into the extract table shown above, it appears as:

	4.5	(4.7)	5.0
35.0	59		55
(35.4)	(59. 8)		(55. 4)
36.0	61		56

The following step is to interpolate for the relative humidity at a temperature of 35.4 and a depression of the wet-bulb temperature of 4.7. The proportion set-up is:

$$\frac{4.7-4.5}{5.0-4.5}=\frac{x}{59.8-55.4} \text{ or } \frac{.2}{.5}=\frac{x}{4.4}\; x=1.76$$

This is subtracted from 59.8 (relative humidity decreases as depression of wet-bulb temperature increases). Thus the relative humidity is 58.04 or 58 to the nearest whole percent.

(3) *Reduction.*—To reduce relative humidities to the nearest whole percent, if the decimal part of the interpolated values is greater than 0.5, the next higher whole number is used; if the decimal part is less than 0.5, the next lower whole number is used. If the decimal part of the interpolated relative humidity is just 0.5, the next higher or the next lower whole percent is used, depending on which is an even number, i. e., a multiple of 2.

46. Station pressure.—*a.* Station pressure is the pressure exerted by the atmosphere at the weather station, at the elevation of the ivory point of the barometer. It is expressed as the height of a column of mercury that would be supported by the atmosphere's pressure if the mercury were at 28.5° C. and the gravity at the station were the same as at 45° N. latitude at sea level. To obtain the true station pressure, the observer must correct the observed barometer reading for any discrepancies from the above conditions. The cor-

rection comprises two parts, a temperature correction and a sum of gravimetric and instrumental corrections. The temperature correction for any set of readings of the barometer and attached thermometer is given by Signal Corps Form No. 80, "Correction of Mercurial Barometer for Temperature," part of which is shown as table IV. Note that for temperatures less than 28.5° F. the correction is positive,

TABLE IV—*Form No. 80*

Form No. 80

WAR DEPARTMENT

SIGNAL CORPS, UNITED STATES ARMY

METEOROLOGICAL SERVICE

CORRECTION OF MERCURIAL BAROMETER FOR TEMPERATURE, ENGLISH MEASURES

HEIGHT OF BAROMETER IN INCHES

°F.	24.0	24.5	25.0	25.5	26.0	26.5	27.0	27.5	28.0	28.5	29.0	29.5	30.0	30.5	31.0	°F.
	Inches						ADD.				*Inches*					
16	.028	.028	.029	.030	.030	.030	.031	.032	.032	.032	.033	.034	.034	.035	.036	16
17	.025	.026	.026	.026	.027	.028	.029	.030	.030	.030	.031	.032	.032	.032	.033	17
18	.023	.024	.024	.024	.025	.026	.026	.026	.027	.028	.028	.028	.029	.030	.030	18
19	.021	.022	.022	.022	.023	.024	.024	.024	.025	.025	.025	.026	.026	.026	.027	19
20	.019	.020	.020	.020	.020	.020	.021	.022	.022	.022	.023	.024	.024	.024	.024	20
21	.017	.017	.017	.018	.018	.018	.019	.019	.019	.020	.020	.020	.021	.022	.022	21
22	.014	.014	.015	.016	.016	.016	.016	.016	.017	.017	.017	.018	.018	.018	.019	22
23	.012	.012	.013	.013	.013	.014	.014	.014	.014	.014	.015	.015	.015	.016	.016	23
24	.010	.010	.011	.011	011	.011	.011	.012	.012	.012	.012	.012	.013	.013	.013	24
25	.008	.008	.008	.008	.009	.009	.009	.009	.009	.010	.010	.010	.010	.010	.010	25
26	.006	.006	.006	.006	.006	.006	.006	.006	.007	.007	.007	.007	.007	.007	.007	26
27	.004	.004	.004	.004	.004	.004	.004	.004	.004	.004	.004	.004	.004	.004	.005	27
28	.001	.001	.001	.001	.001	.002	.002	.002	.002	.002	.002	.002	002	.002	.002	28
	Inches						SUBTRACT				*Inches*					
29	.001	.001	.001	.001	.001	.001	.001	.001	.001	.001	.001	.001	001	.001	.001	29
30	.003	.003	.003	.003	.003	.003	.003	.003	.003	.004	.004	.004	.004	.004	.004	30
31	.005	.005	.005	.005	.006	.006	.006	.006	.006	.006	.006	.006	.006	.007	.007	31
32	.007	.007	.008	.008	.008	.008	.008	.008	.009	.009	.009	.009	.009	.009	.009	32
33	.010	.010	.010	.010	.010	.011	.011	.011	.011	.011	.012	.012	.012	.012	.012	33
34	.012	.012	.012	.012	.013	.013	.013	.013	.014	.014	.014	.014	.015	.015	.015	34
35	.014	.014	.014	.015	.015	.015	.016	.016	.016	.016	.017	.017	.017	.018	.018	35
36	.016	.016	.017	.017	.017	.018	.018	.018	.019	.019	.019	.020	.020	.020	.021	36
37	[illegible]	.019	[illegible]	.019	.020	.020	[illegible]	[illegible]	[illegible]	[illegible]	.022	[illegible]	[illegible]	[illegible]	[illegible]	37
54	.055	.056	.057	.059	.060	.061	.062	.063	.064	.066	.067	.068	.069	.070	.071	54
55	.057	.059	.060	.061	.062	.063	.064	.066	.067	.068	.069	.070	.072	.073	.074	55
56	.060	.061	.062	.063	.064	.066	.067	.068	.069	.071	.072	.073	.074	.076	.077	56
57	.062	.063	.064	.066	.067	.068	.069	.071	.072	.073	.075	.076	.077	.078	.080	57
58	.064	.065	.066	.068	.069	.070	.072	.073	.074	.076	.077	.078	.080	.081	.082	58
59	.066	.067	.069	.070	.072	.073	.074	.076	.077	.078	.080	.081	.083	.084	.085	59
60	.068	.070	.071	.072	.074	.075	.077	.078	.080	.081	.082	.084	.085	.087	.088	60
60.5	.069	.071	.072	.074	.075	.076	.078	.079	.081	.082	.084	.085	.087	.088	.089	60.5
61	.070	.072	.073	.075	.076	.078	.079	.081	.082	.084	.085	.086	.088	.089	.091	61
61.5	.071	.073	.074	.076	.077	.079	.080	.082	.083	.085	.086	.088	.089	.091	.092	61.5
62	.073	.074	.076	.077	.079	.080	.082	.083	.085	.086	.088	.089	.091	.092	.094	62
62.5	.074	.075	.077	.078	.080	.081	.083	.084	.086	.087	.089	.090	.092	.094	.095	62.5
63	.075	.076	.078	.079	.081	.082	.084	.086	.087	.089	.090	.092	.093	.095	.096	63
63.5	.076	.077	.079	.080	.082	.084	.085	.087	.088	.090	.092	.093	.095	.096	.098	63.5
64	.077	.078	.080	.082	.083	.085	.086	.088	.090	.091	.093	.094	.096	.098	.099	64
64.5	.078	.080	.081	.083	.084	.086	.088	.089	.091	.093	.094	.096	.097	.099	.101	64.5

and that for temperatures greater than 28.5° F., the correction is negative.

b. When the observed barometer reading differs from the values heading the column of Form No. 80, i. e., the decimal part of the reading is neither 0.500 nor 0.000, the temperature correction must be obtained by interpolation. Interpolation for the value of the temperature correction is accomplished in the same manner as is interpolation in the case of the dew point, except that the value of the correction is determined to the fourth decimal place and then reduced to the nearest third decimal, i. e., to the nearest one-thousandth of an inch.

Example: Attached thermometer reading: 62.5
Observed barometer reading: 28.852

The pertinent part of Form No. 80 is:

°F	Barometer in inches		
	28.5	(28.852)	29.0
62. 5	. 087	----------	. 089

The following proportion is set up:

$$\frac{.852-.500}{1.000-.500}=\frac{x}{.089-.087} \text{ or } \frac{.352}{.500}=\frac{x}{.002}$$

$$x=.001408$$

The temperature correction is therefore .087+.001, or .088 (subtract).

c. Over part of the range of temperatures the arguments are given for whole degrees only, on Form No. 80. When the attached thermometer reading in this range of temperature is not an even degree, double interpolation is necessary. Here the corrections are determined for the desired pressure at the next higher whole degree of temperature and at the next lower whole degree value. These corrections are determined to the fourth decimal place. Next, the value of the temperature for the observed attached thermometer reading is determined by interpolation between these values and reduced to the nearest thousandth of an inch. If the value of the fourth decimal is exactly between two values to the third decimal place, the correction used is whichever of these has an even figure for its last digit.

d. The following method may be used to save time in single interpolation. On the line for the observed attached thermometer reading on Form No. 80, note the difference between the corrections for the next higher and the next lower pressure values that are given by the

Form No. 79 Met'l

WAR DEPARTMENT
SIGNAL CORPS, UNITED STATES ARMY
METEOROLOGICAL SECTION

BAROMETRIC CORRECTIONS

Signal Corps ....
(Type)
Barometer No. ....
In use at—
....
(Station)
Long. ....
Lat. ....

Station elevation .... ft.
Mean annual temperature .... °F
Mean pressure .... in.
Correction for local gravity: Latitude .... in.; Altitude .... in.
Scale error and capillarity of instrument .... in.
Sum of gravimetric and instrumental corrections .... in.
Removal correction .... ft. .... in.
(Altitude) (Date)
Sum of gravimetric and instrumental corrections .... in.
Removal correction .... ft. .... in.
(Altitude) (Date)
Sum of gravimetric and instrumental corrections .... in.
Removal correction .... ft. .... in.
(Altitude) (Date)
Sum of gravimetric and instrumental corrections .... in.

SPECIAL REMOVAL CORRECTIONS

Temp (Dry bulb)	Elevation	Removal Correction	Sum of Corrections
−20			
−10			
0			
+10			
+20			
+30			
+40			
+50			
+60			
+70			
+80			
+90			
+100			

ATTACHED THERMOMETER No. ....
(Correction in degrees Fahrenheit to reduce to standard air thermometer

Scale Reading	32	42	52	62	72	82	92	100
Correction	0.	0.	-0.	0.	-0.	0.	-0.	-0.

Corrections of 0.5 degree or more will be applied to the observed temperature and the reading thus corrected will be used in determining the correction for temperature of the barometer

FIG. 124.—Form No. 79.

table. If this difference is .001, use the lower correction value if the fractional part of the observed barometer reading is between .000 and .250, or between .500 and .750; if the fractional part of the observed barometer reading is between .251 and 0.500, or between .751 and .000, use the lower correction +.001 (i. e., the greater correction). Where the difference between the two adjacent corrections is .002, use the lower correction when the fractional part of the observed barometer reading is between .000 and .125 or between .500 and .625; use the lower correction +.001, if the fractional part of the observed barometer reading is between .126 and .375, or between .626 and .875; use the lower correction +.002 (i. e., the greater correction) if the fractional part of the observed barometer reading is between .376 and .500, or between .876 and .000. Similar rules apply where the differences between successive tabulated corrections are .003 and .004. The table below summarizes the rules.

Amount to be added to lower value of correction

Difference between adjacent tabulated corrections	.000	.001	.002	.003	.004
.000	All values.				
.001	.001-.250 .500-.750	.250-.500 .750 .000			
.002	.000-.125 .500-.625	.125-.375 .625-.875	.375 .500 .875-.000		
.003	.000-.083 .500-.583	.084-.250 .584-.750	.250-.416 .750-.916	.417-.500 .917-.000	
.004	.000-.062 .500-.562	.063 .187 .563 .687	.188 .412 .686 .912	.413-.437 .913-.937	.438-.500 .938-.000

Example: Barometer reading, 29.687; attached thermometer, 64.0°. The following is an extract from Form No. 80 which applies here:

	29.5	30.0
	Subtract	
64.0	.094	.096

The difference between the tabulated corrections is .002; the fractional part of the observed barometer reading is .687. Enter the third line (.002) of the interpolating table above. Note that .687 is included in the box in the second column over (.626–.875). The amount at the head of that column (.001) is added to the lower correction value (.094), giving a temperature correction of .095. The correction is, negative going under "Subtract."

e. The sum of gravimetric and instrumental corrections comprises all the corrections, except the temperature correction that must be applied to the barometer reading to obtain the corrected station pressure. The sum of correction is fixed for any barometer at any location. Record of the sum of corrections is kept on Form No. 79 which is attached to the barometer case. The last sum of corrections entered on this form is the one used.

f. The total correction is the sum (signs considered) of the temperature correction and the sum of gravimetric and instrumental corrections. If the total correction is negative, it is subtracted from the observed barometer reading; if the correction is positive, it is added to the observed barometer reading. The result is the station pressure which is expressed to the nearest thousandth of an inch.

47. Sea-level pressure.—Sea-level pressure is the theoretical pressure value that would be exerted by the atmosphere at a station at a given time, if that station were at sea level. At low-level stations a fixed amount is added to the station pressure, and the resulting sum is the sea-level pressure in inches. At other stations the temperature during the last 12 hours, as well as the elevation and the latitude, must be considered in determining the sea-level pressure. Tables are prepared for each such station, giving the sea-level pressure for any set of values of station pressure and average temperature during the last 12 hours.

a. Mean temperature, last 12 hours.—The mean temperature for the last 12 hours is one-half the sum of the current air temperature and the air temperature 12 hours earlier. If no observation was taken 12 hours previous to the current observation, the temperature at that time is determined from the thermograph reading. Both the current temperature and the temperature 12 hours ago are taken to the nearest tenth of a degree, added, and divided by two. This average is reduced to the nearest whole degree.

b. Sea-level pressure in inches.—The sea-level pressure is determined from the tables for reduction of station pressure to sea-level pressure for the station. Table V shows part of the tables for reduction of station pressure to sea-level pressure at Chanute Field, Rantoul, Illinois. Note that at the head of each column is a value of station pressure to

an even ten-hundredths (0.10) of an inch, and that at the left of each line is a temperature value which is a multiple of five.

TABLE V.—*For reducing barometer readings to sea level, Chanute Field, Rantoul, Ill.*

Altitude: 744 ft.

Latitude: 40°20′ N.
Longitude: 88°10′ W.

STATION PRESSURE

Temp. °F.	29.60	29.70	28.80	28.90	29.00	29.10	29.20	29.30	29.40	29.50
	Sea-level pressure									
−10	30.49	30.59	29.67	29.77	29.87	29.97	30.08	30.18	30.28	30.28
−5	30.48	30.58	29.66	29.76	29.86	29.96	30.07	30.17	30.27	30.37
0	30.48	30.58	29.65	29.75	29.86	29.96	30.07	30.17	30.27	30.37
5	30.47	30.57	29.64	29.74	29.85	29.95	30.06	30.16	30.26	30.36
10	30.46	30.56	29.64	29.74	29.84	29.94	30.05	30.15	30.25	30.35
15	30.46	30.56	29.63	29.73	29.84	29.94	30.05	30.15	30.25	30.35
20	30.45	30.55	29.63	29.73	29.83	29.93	30.04	30.14	30.24	30.34
25	30.45	30.55	29.62	29.74	29.83	29.93	30.04	30.14	30.24	30.34
30	30.45	30.55	29.62	29.72	29.82	29.92	30.03	30.13	30.24	30.34
35	30.44	30.54	29.61	29.71	29.82	29.92	30.03	30.12	30.23	30.33
40	30.43	30.53	29.61	29.71	29.81	29.91	30.02	30.12	30.22	30.32
45	30.42	30.52	29.60	29.70	29.81	29.91	30.02	30.12	30.22	30.32
50	30.42	30.52	29.60	29.70	29.80	29.90	30.01	30.11	30.21	30.31
55	30.41	30.51	29.59	29.69	29.80	29.90	30.01	30.11	30.21	30.31
60	30.41	30.51	29.59	29.69	29.80	29.90	30.01	30.11	30.21	30.31
65	30.40	30.50	29.58	29.68	29.79	29.89	30.00	30.10	30.20	30.30
70	30.39	30.49	29.58	29.68	29.78	29.88	29.99	30.09	30.19	30.29
75	30.39	30.49	29.57	29.67	29.78	29.88	29.98	30.08	30.19	30.29
80	30.38	30.48	29.57	29.67	29.77	29.87	29.98	30.08	30.18	30.28
85	30.38	30.48	29.56	29.66	29.77	29.87	29.97	30.07	30.18	30.28
90	30.38	30.48	29.56	29.66	29.76	29.86	29.97	30.07	30.17	30.27
95	30.38	30.48	29.55	29.65	29.76	29.86	29.96	30.06	30.17	30.27
100	30.38	30.48	29.55	29.65	29.76	29.86	29.96	30.06	30.17	30.27

(1) If the average temperature to the nearest whole degree is a multiple of five (and therefore appears at the left of the table), and the station pressure, when reduced to the nearest one-hundredth of an inch, actually is to an even tenth of an inch, i. e., the second decimal place has a zero (and therefore the station pressure appears as at the top of the table), the sea-level pressure is taken directly from the table. It is the figure in the column for the given station pressure and on the line for the given average temperature. Thus, if the station pressure is 29.20 inches to the nearest hundredth at Chanute Field, and the average temperature for the last 12 hours is 65° F., the sea level pressure is found in the 29.20 column and on the 65° F. line; it is 30.00 inches.

(2) If the average temperature is a multiple of five, but the station pressure does not reduce to an even tenth of an inch, the sea-level pressure must be determined by interpolation. Interpolation is a method of determining intermediate values from values given in a table. Thus, if the average temperature at Chanute Field is 55° F., and the station pressure to the nearest hundredth of an inch is

29.158 inches, the observer would be concerned with the part of the table shown below:

Temperature	Station pressure	
	29. 10	29. 20
55°	29. 90	30. 01

Since the observed station pressure is 29.16 (to the nearest hundredth of an inch), the following proportion is set up:

$$\frac{29.16-29.10}{29.20-29.10}=\frac{x}{30.01-29.90} \text{ or } \frac{.06}{.10}=\frac{x}{.11}$$

$$x=\frac{.0066}{.10}=.066$$

.07 is the difference between the lower sea-level pressure value and the required sea-level pressure value. Thus, the sea level pressure at Chanute Field in the example above is 29.90+.066=29.966, or 29.97.

(3) If the station pressure reduces to whole tenths of inches and the average temperature to the nearest whole degree is not a multiple of five, the value for the reduced sea-level pressure is obtained by interpolation between the temperature values given in the table for reduction from station pressure to sea-level pressure. Interpolation here is carried out in the same way as in the case given just above. Example: Station pressure at Chanute Field, 29.402 inches; average temperature, 63° F. The part of the table shown below is involved:

Temperature	Station pressure
	29.40
60° F	30. 21
65° F	30. 20

The proportion set-up is:

$$\frac{63-60}{65-60}=\frac{x}{30.21-30.20} \text{ or } \frac{3}{5}=\frac{x}{.01}$$

$$x=\frac{.03}{5}=.006 \text{ or } .01$$

Since 30.21 is the pressure value corresponding to the lower temperature, and since the sea-level pressures decrease as temperatures increase in the table, this .01 must be subtracted from the 30.21, and the result is a sea-level pressure of 30.20. This result could, in this case, have been determined by inspection from the fact that the sea-level pressure would have to be either 30.20 or 30.21 (to the nearest hundredth) since it is between these two values. Because 63° is nearer 65° than 60°, the pressure appropriate to the 65° would naturally be the value determined by inspection, namely 30.20.

(4) If the station pressure is a number not evenly divisible by .10, and the average temperature in the last 12 hours is not divisible by five, the sea-level pressure must be determined by double interpolation. Double interpolation consists of first interpolating to find the values of the sea-level pressure at the temperature given and at the next higher and next lower values of station pressure divisible by .10, and then interpolating between these two values for the sea-level pressure appropriate to the observed station pressure. The sea-level pressures determined for the next higher and the next lower values for station pressure are determined to the nearest thousandth of an inch. When interpolation between these two values is completed, the result is expressed to the nearest hundredth of an inch. Example: At Chanute Field the station pressure is 28.917; the average temperature of the air in the last 12 hours is 67° F.

(*a*) Step 1: Reduce the station pressure to the nearest hundredth of an inch: 28.92.

(*b*) Step 2: Determine the sea-level pressures at the given average temperature for the next higher and the next lower station-pressure values that appear on the chart. The sea-level pressure at 28.90 station pressure and 67° F. is 29.680, by inspection. The sea-level pressure at 29.00 station pressure and 67° F. average temperature is determined by interpolation from the table:

	29. 00
65°	29. 79
70°	29. 78

The proportion set-up in interpolating is:

$$\frac{67-65}{70-65}=\frac{x}{.01} \quad \text{or} \quad \frac{2}{5}=\frac{x}{.01}$$

$$x = .004$$

Since the sea-level pressure is lower for higher average temperatures, .004 must be subtracted from the pressure corresponding to 65° F.:

$$29.79-.004=29.786$$

(*c*) Step 3: Tabulate the results of the single interpolation:

	28. 90	29. 00
63° F	29. 680	29. 786

(*d*) Step 4: Interpolate between the above values of sea-level pressure to find the sea-level pressure corresponding to a station pressure of 28.92.

$$\frac{28.92-28.90}{29.00-28.90}=\frac{x}{29.786-29.680} \quad \text{or} \quad \frac{.02}{.10}=\frac{x}{.106}$$

$$x=.0212 \text{ or } .021$$

Since sea-level pressures increase with increasing station pressures, .021 must be added to 29.680:

$$29.680+.021=29.701$$

(*e*) Step 5: Reduce the sea-level pressure (29.701), to the nearest hundredth of an inch, 29.70.

c. Sea-level pressure in millibars.—Sea-level pressure is finally expressed in millibars. The value in millibars and tenths of a millibar is taken from a conversion table which gives the corresponding expression in millibars (and tenths) for each value of sea-level pressure in inches and hundredths of an inch of mercury. This conversion table is found in appendix I.

48. Altimeter setting.—The altimeter setting is a pressure, in inches and hundredths of an inch, used in setting a pressure-scale type sensitive altimeter in an airplane, such that when the airplane lands at an airport, the altimeter will indicate very closely the elevation of the field above sea level. The altimeter setting is computed on the presumption of a fixed temperature distribution in the atmosphere and thus differs from meteorological sea-level pressure. The altimeter setting is thus determined by the station pressure and the elevation of the station. For each station there is a table giving the altimeter setting in inches and hundredths of an inch for each value of station pressure. The altimeter setting is taken directly from this table without interpolation. Table VI illustrates the table for determining altimeter settings at Chanute Field. Example: The altimeter setting at Chanute Field is 29.94 inches when the station pressure there is 29.15 inches.

TABLE VI.—*Altimeter settings, Chanute Field, Illinois*

Station pressure (inches)	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
28.00	28.76	28.77	28.78	28.79	28.80	28.81	28.82	28.83	28.84	28.85
28.10	28.86	28.87	28.88	28.89	28.90	28.91	28.92	28.93	28.94	28.96
28.20	28.97	28.98	28.99	29.00	29.01	29.02	29.03	29.04	29.05	29.06
28.30	29.07	29.08	29.09	29.10	29.11	29.12	29.13	29.14	29.15	29.16
28.40	29.17	29.18	29.19	29.20	29.21	29.22	29.23	29.24	29.25	29.26
28.50	29.27	29.28	29.29	29.30	29.31	29.31	29.32	29.33	29.34	29.36
28.60	29.37	29.38	29.39	29.40	29.42	29.43	29.44	29.45	29.46	29.47
28.70	29.48	29.49	29.50	29.51	29.52	29.53	29.54	29.55	29.56	29.57
28.80	29.58	29.59	29.60	29.61	29.62	29.63	29.64	29.65	29.66	29.67
28.90	29.68	29.69	29.70	29.71	29.72	29.73	29.74	29.75	29.76	29.77
29.00	29.78	29.79	29.80	29.81	29.82	29.83	29.84	29.85	29.86	29.87
29.10	29.89	29.90	29.91	29.92	29.93	29.94	29.95	29.96	29.97	29.98
29.20	29.99	30.00	30.01	30.02	30.03	30.04	30.05	30.06	30.07	30.08
29.30	30.09	30.10	30.11	30.12	30.13	30.14	30.15	30.16	30.17	30.18
29.40	30.19	30.20	30.21	30.22	30.23	30.24	30.25	30.26	30.27	30.28
29.50	30.29	30.30	30.31	30.32	30.33	30.35	30.36	30.37	30.38	30.39

Station elevation $H_b=744$ ft.

Section III

WINDS-ALOFT OBSERVATION

49. General.—*a. Principle.*—A pilot balloon whose rate of ascent is known, by virtue of its free lift and total lift being selected values, is released and observed. By means of a theodolite, the elevation angle and azimuth of the balloon's position are observed every minute. From the elevation angle and the known height of the balloon at each minute, the horizontal distance of the balloon from the theodolite is computed. The horizontal distance out, together with the azimuth, determine the horizontal projection of the balloon's position for any minute, and this projection is plotted on a plotting board for each minute of the observation. The horizontal movement of the balloon, which is the same as the wind at the elevation of the balloon, is found by noting the direction and distance from point to point.

b. Procedure.—(1) The several parts of the winds-aloft observation are accomplished in the following order:

(*a*) Observing the weather data for Form No. 201.

(*b*) Setting up the theodolite.

(*c*) Inflating the balloon.

(*d*) Releasing the balloon.

(*e*) Observing the balloon, and recording the theodolite readings for each minute of the observation.

(*f*) Replacing the theodolite.

(*g*) Computing the balloon's horizontal distance out, for each minute.

(*h*) Plotting the horizontal projection.

(*i*) Determining the wind direction for each minute.

(*j*) Determining the wind speed for each minute.

(*k*) Completing form 201.

(*l*) Preparing forms and instruments for the next observation.

(2) Ordinarily, the winds-aloft observation is taken by two men, an observer and a recorder. The direct-observation portion of the winds-aloft observation is accomplished by the observer; the record-

Form No. [illegible]
Revised June 1, [illegible]

WAR DEPARTMENT
U. S. SIGNAL CORPS, METEOROLOGICAL SERVICE

PAGE ....

PILOT BALLOON ASCENSION REPORT

Station .... Date .... Starting time ....
Ascension number .... Number of theodolites used .... Time used ....th meridian

Observation point .... Altitude .... ft. | Observation point .... Altitude .... ft.

Minute.	Altitude. yds.	Elevation angle. °	Azimuth angle. °	Distance from observation point. yds.	Wind direction. 0–72	Wind speed. m. p. h.	Minute.	Altitude. yds.	Elevation angle. °	Azimuth angle. °	Distance from observation point. yds.	Wind direction. 0–72	Wind speed. m. p. h.
0	0			Zero setting on			0				Zero setting on		
1	240												
2	460												
3	680												
4	890												
5	1, 100												
6	1, 300												
7	1, 500												
8	1, 700												
9	1, 900												
10	2, 100												
11	2, 300												
12	2, 500												
13	2, 700												
14	2, 900												
15	3, 100												
16	3, 300												
17	3, 500												
18	3, 700												
19	3, 900												
20	4, 100												
21	4, 300												
22	4, 500												
23	4, 700												
24	4, 900												
25	5, 100												
26	5, 300												
27	5, 500												
28	5, 700												
29	5, 900												
30	6, 100												
31	6, 300												

Observer .... Base line .... yds. | Observer .... | Weight balloon .... oz.
Recorder .... Base line azimuth ....° | Recorder .... | Free lift .... oz.
Disappearance due to .... | Dis. due to .... | Total lift .... oz.

Clouds.	Amount.	Kind.	Dir.
Upper			
Lower			

Sun ....
Visibility ....
Temperature ....° F.
Pressure .... in.
Humidity ....%
Surface wind, direction ....
" velocity ....

Tables .... y. p. m.
T—A .... y. p. m.
Type of balloon ....
Type and serial number of theodolite ....
Notes ....

Computer .... | .... Meteorologist in Charge.

U. S. GOVERNMENT PRINTING OFFICE [illegible]
[illegible]

FIGURE 125.—Pilot-balloon ascension report

ing and computation are accomplished by the recorder. The observer prepares the theodolite and the balloon while the recorder observes the weather and enters that data required on Form No. 201. At stations where head-set telephones permit communication between the observation point and the plotting board, the recorder notes the readings taken by the observer and computes the winds aloft while the observation is in progress. Where telephone communication does not permit such an arrangement, the recorder records the observer's readings at the theodolite, and accomplishes the computations after the observation proper is complete. In this case the observer assists the recorder in computation of the observation after the theodolite is put away.

c. Pilot-balloon ascension report.—The complete data of the winds-aloft observation are recorded on Signal Corps Form No. 201, "Pilot Balloon Ascension Report." Entries made on Form No. 201 are made according to the following instructions:

(1) *Page.*—Each observation starts on a page numbered 1. In some cases the complete observation cannot fit on one page. In such cases the observation is continued on a page numbered 2. If for some reason an observation is too short, and a longer observation is possible, a second observation is taken and recorded on the same page if it is taken shortly after the first attempt. It is then recorded on the right-hand half of the form.

(2) *Station.*—The station as indicated on this form should exclusively identify the station, e. g., Chanute Field, Illinois, or Langley Field, Virginia.

(3) *Date.*—The date will be given by month, day of the month, and year.

(4) *Starting time.*—The time of release of the balloon is entered, to the nearest whole minute on a 24-hour clock, local standard time.

(5) *Ascension number.*—The ascension number is one greater than the previous ascension number at the same station. The number indicates how many winds-aloft observations have been taken at the station, and serves as an identification of the observation. If a second or third observation is made immediately after a previous, inadequate observation, and the intervening time is half an hour or less, the several attempts are considered part of one observation and bear the same ascension number.

(6) *Number of theodolites used.*—Except in the case of two theodolite observations, the number of theodolites used is "1."

(7) *Time used.*—The meridian of the local standard time used is

entered. Thus, at Scott Field 90th meridian time is the local standard time, and at Mitchell Field local standard time is that of the 75th meridian.

(8) *Observation point.*—At stations where any of several observation points may be used, each point is designated by a letter—A, B, C, etc. The point used is indicated by the entry of the appropriate letter on Form No. 201.

(9) *Altitude.*—The altitude is the height in feet of the eyepiece of the theodolite above sea level. It is indicated to the nearest whole foot.

(10) *Zero setting.*—The zero setting is a record of the readings of the elevation and azimuth angles made prior to the start of the observation, while the instrument is sighted on one of the station reference points.

(11) *Elevation angle.*—For each minute the elevation angle, as read from the theodolite, is entered to the nearest tenth of a degree.

(12) *Azimuth angle.*—For each minute the azimuth angle, as read from the theodolite, is entered to the nearest tenth of a degree.

(13) *Distance from observation point.*—The horizontal distance of the balloon from the observation point is indicated as computed for each minute. The distance is expressed in yards to the nearest 10 yards.

(14) *Wind direction.*—(*a*) The wind direction is usually entered on the basis of a 36-point scale, and any number from 0 to 36 may be entered for any minute in the direction column. The zero (0) is used when there is no air movement; 36 indicates a north wind (360°); 14 indicates a wind from 140°. The use of a 36-point direction scale is indicated by the entry of "0—36" in the column heading.

(*b*) When a 64-point wind direction scale, corresponding to 64 points of the compass, is used, this fact is indicated at the head of the wind direction column by the entry of "0—64." In this case "64" would represent a north wind; "20" would indicate an east-southeast wind; "40" would represent a southwest wind.

(15) *Wind speed.*—The wind speed is indicated for each minute of the observation to the nearest mile per hour.

(16) *Observer.*—The grade and name of the observer are indicated.

(17) *Recorder.*—The grade and name of the recorder are indicated.

(18) *Base line and base-line azimuth.* These spaces are left blank in single theodolite winds-aloft observations.

(19) "*Disappearance due to.*"—The cause of termination of the observation is indicated. The balloon may be lost from sight due to

"distance" if it is 10,000 yards from the observation point. Otherwise the reason for disappearance may be "smoke," "entering base of Cu," "entering side of cloud," "obscuring by Fs," "burst," "vibration of theodolite," etc. When the pilot balloon is still visible after the observation has lasted 25 minutes, and there is no requirement for winds at higher elevations, the observation may be terminated, and the word "abandoned" entered in the space for cause of disappearance of the balloon.

(20) *Weight of balloon.*—The weight of the balloon is recorded to the nearest hundredth of an ounce. When a lantern is to be tied to a balloon for a night observation, the sum of the weights of the balloon, string, and lantern is entered.

(21) *Free lift.*—The free lift of the inflated balloon is indicated to the nearest hundredth of an ounce.

(22) *Total lift.*—The total lift of the balloon is entered to the nearest hundredth of an ounce. This is the sum of the weight of the balloon (plus lantern) and the free lift.

(23) *Clouds.*—The number of tenths of each type of cloud visible and its direction of motion are recorded here. Upper clouds (cirrus, cirrocumulus, cirrostratus) are recorded in the first two lines; middle clouds (altocumulus, altostratus) are recorded on the third and fourth lines; low clouds (stratocumulus, stratus, nimbostratus, cumulus, cumulonimbus) are recorded on the last two lines of the cloud space. Standard abbreviations are used for the cloud types. The direction from which the clouds are moving is indicated to the nearest of the eight points of the compass.

(24) *Sun.*—The appearance of the sun to the observer is recorded. Ordinarily an unobscured sun is recorded as "bright." It may be "very bright." When the sun is obscured or dimmed by atmospheric phenomena, indication is made of the obscuring, e. g., "Sun obscured by St.," "Sun smoky," etc.

(25) *Visibility.*—The visibility is indicated in miles (and fractions of a mile when less than three miles).

(26) *Temperature.*—The temperature of the air is indicated to the nearest tenth of a degree, Fahrenheit

(27) *Pressure.*—The sea-level pressure is indicated as computed to the nearest hundredth of an inch of mercury.

(28) *Humidity.*—The relative humidity is indicated to the nearest whole percent.

(29) *Surface wind, direction.*—The direction of the surface wind is expressed according to the same scale as are the wind directions aloft.

The surface-wind direction is determined from the 10-second reading of the azimuth angle.

(30) *Surface wind, velocity.*—The speed of the surface wind is indicated in miles per hour. At stations equipped with anemometers, the wind speed is taken from the anemometer reading. When an anemometer is not available, the surface wind speed is computed from the 10-second elevation angle.

(31) *Tables.*—The tables ordinarily in use are those for a rate of rise of 200 yards per minute. When these are used, this rate of rise is indicated. When tables are not used, indication is made by the entry of a dash (—) in the space for tables.

(32) *T—A.*—This entry is omitted. It was originally intended to be the rate of ascent as obtained from a time-altitude curve for two-theodolite observations.

(33) *Type of balloon.*—The type of balloon is indicated by type number. The standard types are ML–50, ML–51, and ML–64, uncolored, black, and red respectively; they are approximately 6 inches in diameter when uninflated.

(34) *Notes.*—Any significant information pertinent to the winds-aloft observation that is not entered elsewhere would be noted in this space. Weather and obstructions to visibility are the most common entries.

(35) *Computer.*—The name of the computer is entered in the space provided.

(36) *Meteorologist in charge.*—The signature or stamp of the weather officer or noncommissioned officer in charge of the station is entered here and indicates that the report has been checked.

(37) *Teletype report.*—At stations whose winds-aloft observations are placed on teletype circuits, the teletype message is entered on the line immediately above the last. When the rate of ascent is different from 200 yards per minute, the observation is recorded on the right-hand half of Form No. 201. The derived horizontal distance, wind direction, and wind speed are also entered on this half of the page.

50. Selection and preparation of theodolite position.—*a. Selection of theodolite position.*—The theodolite's position should be so selected as to permit a view of the sky in all directions, with no buildings or other obstructions obscuring the sky at an elevation angle of more than 6°. The ground (or roof or base) upon which the theodolite stands must be firm so that the instrument does not move. At permanent stations, the observation point will, of course, be prepared more thoroughly than at a temporary station. Alternative theodolite positions must be prepared if one position does not present

an unobscured view of the sky in all directions. The observation point from which the best observation can be taken under existing conditions is used at any specific observation.

b. Initial orientation of theodolite.—(1) *By magnetic compass.*— The following steps are taken:

(*a*) Place a magnetic compass at the center of the theodolite position.

(*b*) Turn the compass so that the line of sight through the eyepiece of the compass coincides with the compass needle. This is the direction of magnetic north.

(*c*) Sight through the eyepiece of the compass and pick a clearly defined fixed point some distance away on the line of sight. (If no appropriate point appears to the north, turn the line of sight to some other definite direction, say south or northwest and choose a prominent point in that direction.) Make a note of this point.

(*d*) Remove the compass, and set up the theodolite so that it is level and centered over the previous position of the compass.

(*e*) Determine the magnetic declination for the station from geodetic tables or from a recent navigation map.

(*f*) Turn the theodolite so that the reading on the horizontal circle is equal to the magnetic declination, if the declination is east, or equal to 360° minus the declination if the declination is west. Engage the horizontal-tangent screw at this reading. (If a direction other than magnetic north has been chosen along which the fixed point is taken, the declination is added to the magnetic direction in degrees of the selected point, and this angle is the reading required on the horizontal circle. If the declination is west, it is subtracted from the magnetic direction in degrees, and the required horizontal-circle reading is thus obtained.)

(*g*) With the horizontal-tangent screw undisturbed and the base plate unclamped and vertical-tangent screw free to turn, the theodolite is pointed at the fixed point. The base plate clamp is locked. The base-plate slow-motion screw is used to center the fixed point in the field of view. The horizontal-circle reading is checked to see that it has not changed. The theodolite is now oriented with the zero reading on true north.

(2) *By the sun.*—(*a*) At true solar noon, the sun is on the meridian, i. e., the north-south line through the station. The theodolite may be oriented by sighting on the sun at true solar noon. True solar time is determined by correcting local standard time. If the local standard-time meridian is west of the station, 4 minutes of time are added to the local standard time for each degree of difference of longitude

between the station and the standard meridian. If the standard meridian is east of the station, 4 minutes per degree difference in longitude are subtracted from the local standard time. The time thus obtained is local mean time.

(*b*) To convert local mean time to true solar time, account must be taken of the annual variation of length of the day. This variation

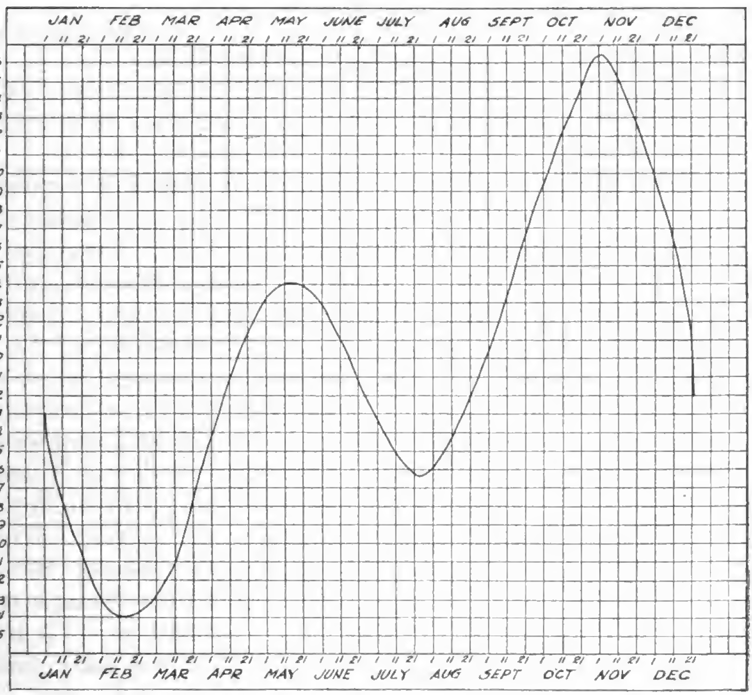


FIGURE 126.—Equation of time-graph.

is described by the equation of time which indicates the correction to be applied to local mean time to obtain true solar time for any date. In the graph of the equation of time as shown in figure 126, for dates where the curve has a positive ordinate, the correction is added to the local mean time; where the ordinate is negative, the correction is subtracted from the local mean time. The time thus obtained is true solar time. At 12:00 noon, true solar time, the sun is on the local meridian, i. e., either north or south.

(*c*) The sun is always south of latitude 23½° N. and always north of latitude 23½° S. Theodolites are not ordinarily oriented by the sun in the tropics (23½° S. to 23½° N.). North of the tropics, the

theodolite is initially oriented by the sun by the observer's engaging the horizontal-tangent screw at a reading of 180.0°, and directing the theodolite so that the sun is centered in the field of view by varying the elevation angle and the orientation of the base plate, using the base-plate slow-motion screw if necessary. When the base plate is clamped, with the horizontal reading 180.0°, and the sun centered in the field of view at true solar noon, the theodolite is properly oriented. South of the tropics, the procedure is the same except that the horizontal tangent screw is engaged at a reading of 0.0°.

(*d*) When the theodolite is directed at the sun, care must be taken that the objective lens is covered by smoked glass or overexposed film.

(3) *By the position of Polaris.*—(*a*) The star, Polaris, is very close to true north. However, its position relative to the earth varies slightly with time. The variation of the position of Polaris from true north has been determined accurately, so that when tables of corrections for the variation of Polaris are used, true north may be determined accurately from Polaris' position. Table VII is a table of the variation of Polaris from true north, computed for several times during the first of each month for various latitudes. A correction that applies at a given time on any one day will apply 3.93 minutes earlier the next day and 3.93 minutes still earlier the next day after that, etc. Thus, one can determine from the tables the time at which any of the tabulated corrections will apply on any day of the year. Thus, on February 1, the variation at Bismarck, North Dakota, 46°47′ N., 100°38′ W., is +1.5 at 10:54 PM, true solar time (Polaris west of north). On February 11, the variation at Bismark is +1.5 at 10:54 PM minus 10×3.93 minutes, or at 10:15 PM, true solar time. In order to use this information in orienting the theodolite, the equivalent local standard time must be determined. First, the true solar time is converted to local mean time by use of the equation of time. On February 11, it appears from figure 126 that—

True solar time—local mean time=—14 min.
True solar time=10:15 PM
10:15 PM—local mean time=—14 min.
Local mean time=10:01 PM

(*b*) Secondly, local mean time must be converted to local standard time. Local standard time at Bismark is 105th-meridian time. Local mean time exceeds local standard time by 4° for each degree of longitude that the station lies east of the standard meridian. Thus, local mean time at Bismark, 100°38′ W., which is 4°22′ east of the

standard meridian, is 17 minutes later than 105th-meridian time. The standard time corresponding to local mean time on February 11 must be 10:01 PM—17 minutes, or 9:44 PM At 9:44 PM, local standard time, the variation of Polaris from true north at Bismark, North Dakota, is +1.5.

TABLE VII.—*Variation of Polaris from north*

[When sign is plus, Polaris is west of north. Not to be used after Jan. 1, 1955]

Change per day—3.93 min. North latitude

Date and time			25° and less	30°	35°	40°	45°	50°	55°	60°	65°	70°
Jan. 1	**Feb. 1**	**Mar. 1**	°	°	°	°	°	°	°	°	°	°
6:58P	4:55P	3:05P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9:57P	7:55P	6:04P	+0.8	+0.8	+0.9	+1.0	+1.1	+1.2	+1.3	+1.5	+1.8	+2.2
1:01A	10:54P	9:04P	+1.1	+1.2	+1.3	+1.4	+1.5	+1.6	+1.8	+2.1	+2.5	+3.0
4:00A	1:58A	12:07A	+0.8	+0.8	+0.9	+0.9	+1.0	+1.1	+1.2	+1.4	+1.6	+2.1
7:00A	4:57A	3:07A	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9:59A	7:57A	6:06A	−0.8	−0.8	−0.9	−0.9	−1.0	−1.1	−1.2	−1.4	−1.6	−2.1
12:59P	10:56A	9:06A	−1.1	−1.2	−1.3	−1.4	−1.5	−1.6	−1.8	−2.0	−2.4	−3.0
3:58P	1:56P	12:05P	−0.8	−0.8	−0.9	−1.0	−1.1	−1.2	−1.3	−1.5	−1.8	−2.2
Apr. 1	**May 1**	**June 1**										
1:03P	11:05A	9:03A	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4:02P	2:04P	12:03P	+0.8	+0.8	+0.9	+1.0	+1.1	+1.2	+1.3	+1.5	+1.8	+2.2
7:02P	5:04P	3:02P	+1.1	+1.2	+1.3	+1.4	+1.5	+1.6	+1.8	+2.1	+2.5	+3.0
10:01P	8:03P	6:02P	−0.8	−0.8	−0.9	−0.9	−1.0	−1.1	−1.2	−1.4	−1.6	−2.1
1:05A	11:03P	9:01P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4:04A	2:06A	12:05A	−0.8	−0.8	−0.9	−0.9	−1.0	−1.1	−1.2	−1.4	−1.6	−2.1
7:04A	5:06A	3:04A	−1.1	−1.2	−1.3	−1.4	−1.5	−1.6	−1.8	−2.0	−2.4	−3.0
10:03A	8:05A	6:04A	−0.8	−0.8	−0.9	−1.0	−1.1	−1.2	−1.3	−1.5	−1.8	−2.2
July 1	**Aug. 1**	**Sept. 1**										
7:06A	5:05A	3:03A	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10:05A	8:04A	6:03A	+0.8	+0.8	+0.9	+1.0	+1.1	+1.2	+1.3	+1.5	+1.8	+2.2
1:05P	11:04A	9:02A	+1.1	+1.2	+1.3	+1.4	+1.5	+1.6	+1.8	+2.1	+2.5	+3.0
4:04P	2:03P	12:02P	+0.8	+0.8	+0.9	+0.9	+1.0	+1.1	+1.2	+1.4	+1.6	+2.1
7:04P	5:03P	3:01P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10:03P	8:02P	6:01P	−0.8	−0.8	−0.9	−0.9	−1.0	−1.1	−1.2	−1.4	−1.6	−2.1
1:07A	11:02P	9:00P	−1.1	−1.2	−1.3	−1.4	−1.5	−1.6	−1.8	−2.0	−2.4	−3.0
4:06A	2:05A	12:04A	−0.8	−0.8	−0.9	−1.0	−1.1	−1.2	−1.3	−1.5	−1.8	−2.2
Oct. 1	**Nov. 1**	**Dec. 1**										
1:06A	11:00P	9:02P	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4:05A	2:04A	12:05A	−0.8	−0.8	−0.9	−1.0	−1.1	−1.2	−1.3	−1.5	−1.8	−2.2
7:05A	5:03A	3:05A	−1.1	−1.2	−1.3	−1.4	−1.5	−1.6	−1.8	−2.1	−2.5	−3.0
10:04A	8:03A	6:04A	+0.8	+0.8	+0.9	+0.9	+1.0	+1.1	+1.2	+1.4	+1.6	+2.1
1:04P	11:02A	9:04A	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4:03P	2:02P	12:03P	−0.8	−0.8	−0.9	−0.9	−1.0	−1.1	−1.2	−1.4	−1.6	−2.1
7:03P	5:01P	3:03P	−1.1	−1.2	−1.3	−1.4	−1.5	−1.6	−1.8	−2.0	−2.4	−3.0
10:02P	8:01P	6:02P	−0.8	−0.8	−0.9	−1.0	−1.1	−1.2	−1.3	−1.5	−1.8	−2.2

(*c*) The azimuth of Polaris is determined from the variation. If the variation is negative (east), the azimuth of Polaris is equal to the

variation; if the variation is positive (west), the azimuth of Polaris is equal to 360° minus the variation.

(*d*) The theodolite is initially oriented by engaging the horizontal-tangent screw at the reading equal to the azimuth of Polaris at the time, and centering Polaris by varying the angle of elevation and the orientation of the base plate, using the base-plate slow-motion screw for a fine adjustment. When the base plate is clamped, with the

FIGURE 127.—Ursa Major and Polaris.

horizontal-circle reading equal to the azimuth of Polaris at the time, and Polaris centered in the field of view, the theodolite is properly oriented. Figure 127 shows the position of Polaris relative to the constellation Ursa Major (the big dipper).

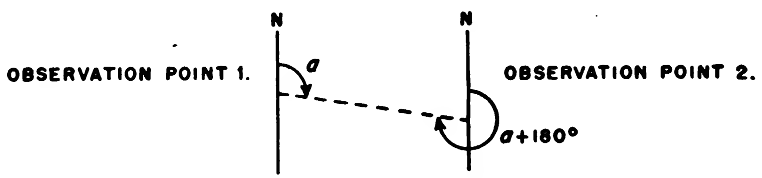


FIGURE 128.—True north by transference.

(4) *By transference.*—(*a*) Orientation of the theodolite by transference is the orientation of a theodolite at one position, given the proper orientation at another position. From figure 128 it may be seen that the azimuth of the second position taken at the first, differs by 180° from the azimuth of the first position taken at the second.

(*b*) The orientation is accomplished by directly obtaining the azimuth of the new position taken at the position whose orientation is known. If this azimuth is greater than 180°, 180° is subtracted from it; if this azimuth is less than 180°, 180° is added to it. The resulting value is the azimuth of the old position from the new one. The theodolite is properly set up and leveled at the new position, and the horizontal-tangent screw is engaged at a reading equal to the value of the azimuth of the old position from the new one. By varying the orientation of the base plate and the value of the angle of elevation, using the base-plate slow-motion screw for a fine adjust-

ment, the theodolite is so directed as to have the old theodolite position centered in the field of view. When the base plate is clamped, with the horizontal-circle reading equal to the azimuth of the old position taken at the new one, and the old position centered in the field of view, the theodolite is properly oriented.

c. Reference points for theodolite position.—To permit rapid orientation of the theodolite when setting it up for an observation, reference points are determined for each theodolite position. A reference point must be a clearly defined, fixed point. A distant point is more desirable as a reference point than a nearby one because it permits greater accuracy in orienting the theodolite. Several reference points should be established for each theodolite position, to provide alternates in the case of one being obscured. Special reference points must be established for nighttime orientation. The azimuth and the angle of elevation of each reference point are noted from the scale readings when the theodolite is initially oriented. Such azimuth readings are determined for each reference point for each theodolite position. These readings are posted in a convenient place in the station, and a record is kept of them in the files.

d. Instrumental installations.—Wherever possible, the theodolite positions should have telephone connection to the plotting board, and lighting equipment for observations during darkness. Provision for a special theodolite base at permanent stations is desirable.

51. Preparation of theodolite for observation.—*a. Setting up theodolite.*—Where a permanent theodolite base is available, setting up of the theodolite is accomplished by placing the feet of the tripod in a set of prepared holes or stays. Where there is no prepared theodolite base, care must be taken that the theodolite is—

(1) Centered over the center of the theodolite position.

(2) Stable, not liable to fall over when disturbed.

(3) Level.

b. Leveling theodolite.—(1) *Theodolite with four leveling screws.*—Turn the head of the theodolite so that each level on it is parallel to an imaginary line connecting two diagonally opposite leveling screws. Turn the leveling screws in diagonally opposite pairs in such a manner as to level one of the levels and then the other. Keep the screws turned so as to prevent the theodolite head from rocking on the leveling screws. When the bubbles in both of the levels have been centered, turn the theodolite head around and check to see that the levels indicate that the instrument is level in whatever direction it is turned.

(2) *Theodolite with three leveling screws.*—Turn the head of the theodolite so that the standard level is parallel to a line connecting two of the leveling screws. Turn either or both of these screws until the bubble is centered in the standard level. Turn the third leveling screw until the other level, the plate level, is also horizontal. Check the standard level. If the bubble has been displaced from the center, recenter it; recenter the bubble in the plate level if necessary. When both bubbles are centered in their respective levels, the head of the theodolite is turned 90° about the vertical axis to check the leveling further. If the bubbles remain centered, the theodolite is level.

c. Orienting theodolite.—After the theodolite has been leveled, the instrument is oriented by engaging the horizontal- and elevation-tangent screws so that the horizontal- and vertical-circle readings are equal to the readings of an appropriate reference point. The head of the theodolite is turned with the base plate so that the reference point is centered in the field of view, the base-plate slow-motion screw being used for a fine adjustment. When the base plate is clamped, with the reference point centered on the crosshairs, and the elevation and azimuth angles reading the same as prescribed for the given reference point, the theodolite is properly oriented.

52. Preparation of pilot balloon for observation.—*a. Care of balloons and hydrogen.*—(1) Pilot balloons should be kept in a cool, dry, dark place, well covered with talc. They are thus protected from deteriorating in storage. Before a balloon is to be used for an observation, it should be warmed uniformly by being kept inside one's blouse for a few minutes, or by rubbing with the hands. A balloon should be released shortly after it has been inflated.

(2) Hydrogen is stored in steel cylinders, each containing the equivalent of 180 to 200 cubic feet of hydrogen at standard pressure. This amount of gas is sufficient to inflate twenty to twenty-five 6-inch pilot balloons. The hydrogen cylinders must be kept in a well-ventilated place; the ventilation must provide for removal of any hydrogen which might collect at the ceiling. The cylinders must be protected from excessive heat. Smoking or the lighting of matches or candles must not be permitted in any enclosed storage place for hydrogen cylinders.

b. Free lift and rate of ascent of pilot balloon.—(1) The free lift of a balloon is the upward force on it due to its being lighter than the surrounding air. The total lift of a balloon is the sum of its free lift and the weight of the balloon and any attachment to it. These are expressed in ounces to the nearest hundredth. The weight of the

standard 6-inch pilot balloon is 1.06 ounces. Slight differences from this weight are inconsequential to the rate of rise of the inflated balloon. Unless a balloon other than the standard 6-inch balloon is used, its weight is noted as 1.06 ounces.

(2) The relation between the rate of ascent and the total lift and free lift is given by the formula:

$$A=158\left(\frac{F_{2/3}}{T}\right)^{5/8}$$

where A = rate of ascent in yards per minute.
F = free lift in ounces.
T = total lift in ounces.

(3) For a standard pilot balloon with a free lift of 4.66 ounces, the rate of ascent is 200 yards per minute above the turbulent air which is near the ground. In the turbulent layer, the rate of rise is 240 yards per minute during the first minute, 220 yards per minute during the second minute, 220 yards per minute during the third minute and 210 yards per minute during the fourth and fifth minutes. Ordinarily, by the end of the fifth minute the balloon is above the turbulent layer and rises 200 yards per minute.

(4) Balloons having different rates of ascent than 200 yards per minute also rise more rapidly than the calculated rate of ascent while they are in the turbulent air in the first thousand yards above the earth's surface. The excess rate of rise in the turbulent layer, in any case, is proportional to the excess rate of rise for the standard balloon in the turbulent layer.

c. *Selection of pilot balloon.*—Pilot balloons of three colors are in use in the Weather Service. They are the ML–50, uncolored, the ML–51, black, and the ML–64, red. The uncolored balloon is best used when the sky is clear; the black balloon is most suitable for cloudy skies; the red balloon is desirable for use when the sky is partly cloudy, when the clouds are thin, or when haze is present.

d. *Inflating pilot balloon.*—The apparatus for inflating the pilot balloon consists of a rubber hose, on one end of which is a coupling which connects it to the hydrogen cylinder, and on the other end of which fits a hosecock that weighs 4.66 ounces. The following instructions govern the inflation of the pilot balloon:

(1) Fasten the balloon to the wide end of the hosecock by means of two small rubber bands.

(2) With the jet of the hosecock open, expel all the air from the balloon by compressing the balloon in your hands, and then close the jet of the hosecock.

(3) Open the valve of the hydrogen cylinder, to which is attached the rubber hose, long enough to expel any air that may be in the hose; then close the valve.

(4) Insert the smaller end of the hosecock into the free end of the rubber hose and open the jet of the hosecock.

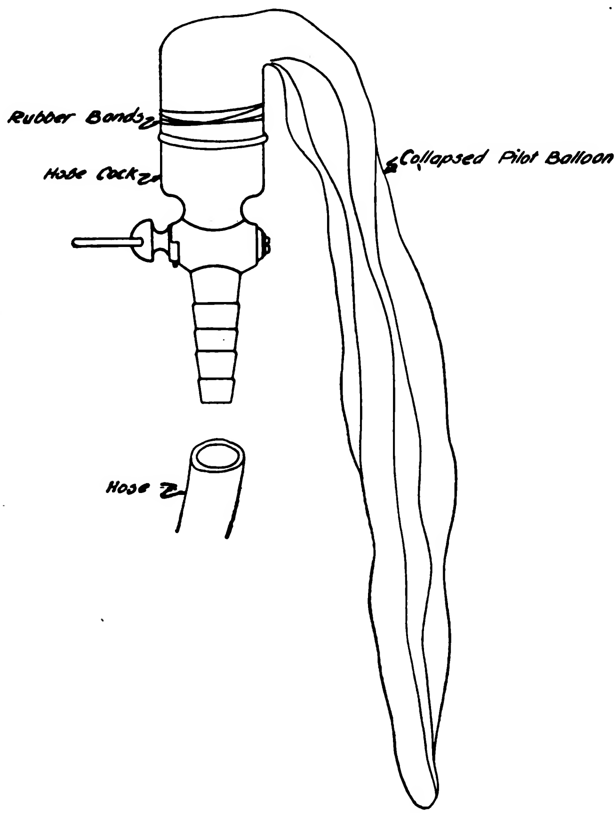


FIGURE 129.—Pilot balloon about to be inflated.

(5) Open the valve of the hydrogen cylinder and permit the hydrogen to fill the pilot balloon. Shut the valve when sufficient hydrogen is in the balloon to sustain or slightly lift the balloon and the hosecock.

(6) Shut the jet of the hosecock, and remove the hosecock from the hose.

(7) If the balloon and hosecock tend to settle, insert the hosecock into the free end of the hose, open the jet, and by opening the valve of the hydrogen cylinder permit sufficient hydrogen to flow into the balloon to sustain or lift the balloon and hosecock.

(8) If the balloon and hosecock tend to rise, open the jet of the hosecock to permit sufficient hydrogen to escape until the balloon and hosecock tend to float in the air without rising or settling.

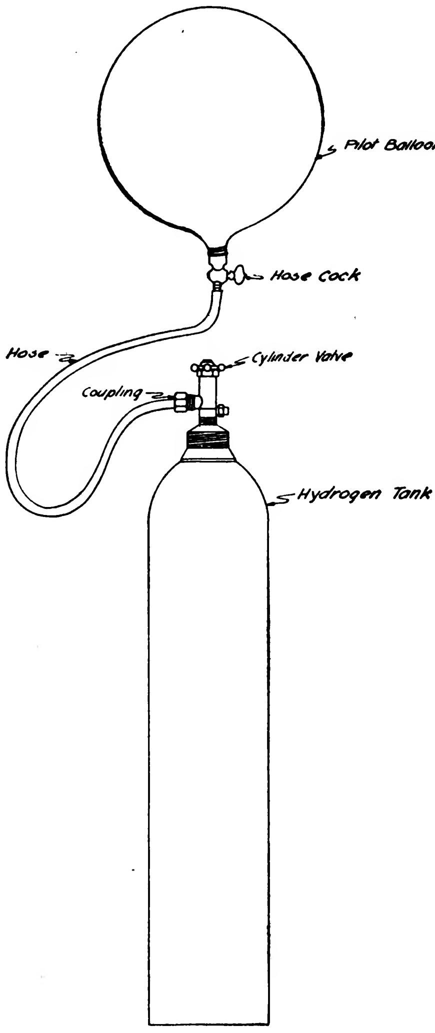


FIGURE 130.—Inflating the pilot balloon.

(9) When the balloon has been properly inflated, twist the neck of the balloon several times so that it doubles on itself. Remove the hosecock from the balloon's mouth. Tie the mouth of the balloon

by passing the rubber bands several times around the twisted neck of the balloon. The balloon is then ready for the observation.

e. Balloons for night observations.—The night observation is accomplished by attaching a paper lantern to the balloon and using the lantern as a target for the theodolite. The candle is fastened to the bottom of the lantern by a drop of melted wax, or by an ordinary pin

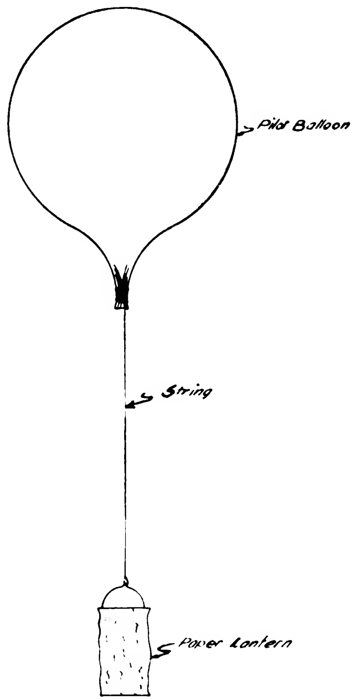


FIGURE 131.—Pilot balloon with lantern attached.

or thumbtack sticking vertically through the bottom of the lantern into the candle. A cord, 4 feet long, is used to tie the top of the lantern to the neck of the balloon. When the balloon is being inflated, the lantern, including the candle and string, are attached to the small hook on the hosecock, and the balloon is so inflated as barely to sustain the hosecock and complete lantern. When everything is in readiness for the observation, the observer lights the candle, taking care that the lantern does not catch fire.

53. Observing pilot balloon.—*a. Timing.*—When the theodolite has been oriented and the balloon properly inflated, and both the recorder and the observer are at their posts ready to take the winds-

aloft observation, the recorder consults his watch. He calls "Ready" when the second hand indicates 55 seconds, and "Release" when the second hand indicates the even minute. When the second hand indicates 5 seconds, the observer calls "Warning," and at 10 seconds he calls "Read." Whenever, thereafter, the second hand indicates 55 seconds, the recorder calls out "Warning," and at the even minute

FIGURE 132.—Sighting the balloon through the gunsights.

he calls out "Read." At some stations, a buzzer clock is available which buzzes at alternating intervals of 55 seconds and 5 seconds. These buzzes are used as the warning and reading signals, respectively.

b. Releasing balloon.—When the recorder calls "Release," the observer releases the balloon. The observer must take care that the balloon does not strike any nearby object. In the case of an observation during darkness, it is necessary that the balloon and lantern be so released as not to cause the lantern to be jerked and the lighted candle

extinguished or the lantern set afire. Special care is necessary when the wind is fresh or gusts are occurring.

c. Sighting balloon with gunsights.—As soon as he releases the balloon, the observer disengages the horizontal- and the vertical-tangent screws and turns the theodolite in the general direction of the balloon. When the recorder calls the 5-second "warning," the observer sights along the gunsights and turns the theodolite about its vertical and horizontal axes so that the gunsights are aimed directly

FIGURE 133.—Observing the pilot balloon.

at the balloon (or lantern). While so aiming the theodolite, the observer keeps the telescope steady by so grasping the theodolite that the fingers of his right hand are on top of the horizontal circle, his thumb underneath the base plate, the fingers of his left hand are behind the vertical-circle support, and his left thumb is on the face of the vertical circle.

d. Ten-second reading.—When the recorder calls "Read," 10 seconds

after the balloon has been released, the observer reads the elevation angle and the azimuth angle aloud, without engaging the tangent screws. These readings are made to the nearest tenth of a degree.

e. Observing pilot balloon.—Having taken the 10-second reading, the observer realines the gunsights on the balloon and quickly looks into the eyepiece. If the balloon is not in the field of view, the observer once more alines the gunsights on the balloon and observes through the eyepiece for the balloon. When the balloon appears in the field of view, the observer carefully engages the tangent screws one at a time and continues to keep the balloon at the center of the field of view by manipulating the tangent screws.

f. Reading elevation and azimuth angles.—(1) Each minute, when the recorder calls "read," the observer reads the elevation angle and the azimuth angle aloud in that order. When the balloon is changing

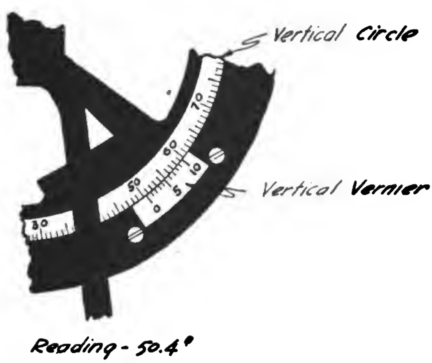


FIGURE 134.—Elevation-angle reading from vernier.

direction rapidly, it may be necessary for the observer to look into the theodolite to recenter the balloon after reading the elevation angle and before reading the azimuth angle. This is to prevent his losing sight of the balloon.

(2) The angles are observed to the nearest tenth of a degree. On theodolites with micrometer-type tangent screws, the number of tenths indicated by the vertical-circle tangent-screw micrometer drum is added to the whole degrees indicated by the direct reading of the vertical circle, to obtain the angle of elevation. Similarly, the number of tenths indicated by the horizontal-circle tangent-screw drum is added to the whole degrees of the direct horizontal-circle reading to obtain the azimuth angle.

(3) On theodolites equipped with verniers, the readings are obtained

directly from the vertical circle and its vernier, and from the front horizontal circle and its vernier.

(4) In reading the angles, the observer calls them out digit by digit, indicating the decimal point by "point." Thus, 136.2 would be read as "one three six point two," and 3.0 would be called out as "three point zero."

g. Conclusion of observation.—The observation of the pilot balloon is concluded by the disappearance of the balloon or by its being abandoned. When the balloon is still visible, it may be abandoned if all the local purposes of the observation have been accomplished and the observation has lasted 25 minutes.

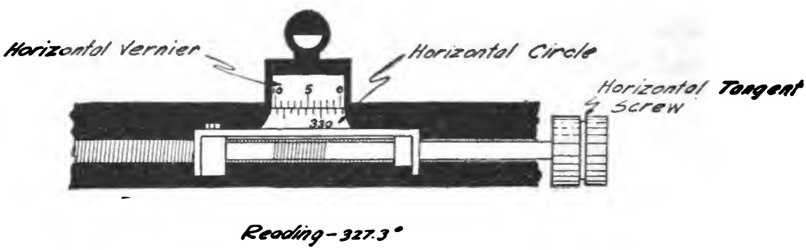


FIGURE 135.—Azimuth-angle reading from vernier.

h. Replacing theodolite.—When the observation has been completed, the observer rechecks the leveling and orientation of the theodolite. The orientation is checked by sighting the instrument on the chosen reference point and reading the elevation and azimuth angles. These readings should be the same as the original zero setting at the time of starting the observation. The theodolite is then returned by the observer to its place of regular storage.

54. Recording observation.—The recorder writes the angle readings in the appropriate spaces as the observer reads them. The 10-second readings are entered on the right margin. He should notice any peculiar readings and require checks on them. If the rate of ascent is different from 200 yards per minute, all the data are entered on the right-hand side of Form No. 201.

55. Determining horizontal distance of pilot balloon.—Several methods may be used to compute the horizontal distance of the pilot balloon from the observation point, using the angle of elevation and the height of the balloon.

a. Tables.—When the regular rate of ascent of the pilot balloon is 200 yards per minute, the horizontal distance of the pilot balloon is determined most readily from tables of Circular 8–14, Office of the Chief Signal Officer. In this circular, each table, printed on two

pages facing each other, corresponds to the altitude of the pilot balloon at each of the first 30 minutes of ascent of the balloon under standard conditions. The horizontal distance of the balloon at any minute is

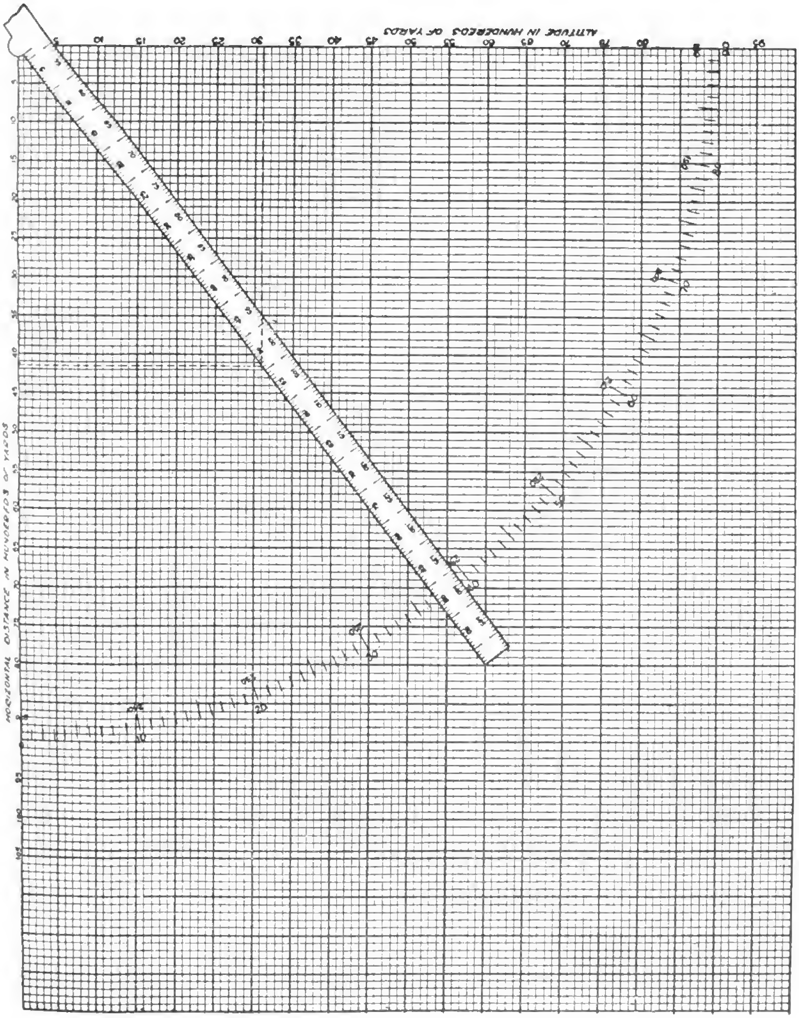


FIGURE 136.—Use of the grid in determining horizontal distance.

found on the table corresponding to that minute, on the line corresponding to the number of whole degrees of the angle of elevation, and in the column corresponding to the number of tenths of a degree in the decimal part of the angle of elevation. This distance is given in yards.

b. Plotting board.—The horizontal distance of the pilot balloon may be determined graphically on the lower left-hand corner of plotting board ML-55. The ordinate of the grid on ML-55 is the altitude of the balloon, and the abscissa is the horizontal distance. The angle of elevation is indicated by the figure on the outside of the protractor-circle quadrant printed on the lower left-hand portion of the plotting board. The procedure in determining the horizontal distance of the balloon is:

(1) Orient the brass rule so that the edge passing through the center peg also passes through the value of the angle of elevation, on the outside angular scale in the lower-left quadrant of the plotting board.

(2) Find the altitude of the balloon on the right-hand edge of the grid, and find the point where the horizontal line through that altitude intersects the edge of the brass rule passing through the center peg.

(3) Follow the ordinate through that point upward to where it intersects the topmost line of the grid, and read the horizontal distance corresponding to that intersection.

c. Trigonometric method.—The horizontal distance may be computed by trigonometry with the use of tables of natural tangents or cotangents. The triangle to be solved is:

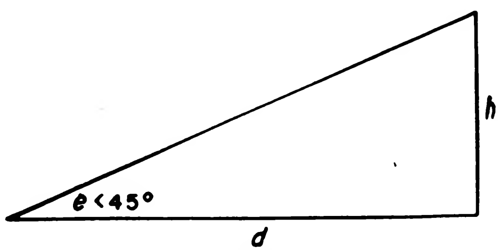


FIGURE 137.—Pilot-balloon triangle.

where e=angle of elevation, d=horizontal distance of balloon from theodolite station, and h=height of the balloon.

$$\tan e = h/d \qquad \text{or} \qquad \cot e = d/h$$
$$d = h/\tan e \qquad\qquad d = h \cot e$$

The horizontal distance of the pilot balloon is computed by dividing the height by the value of the tangent of the angle of elevation, or by multiplying the height by the cotangent of the angle of elevation.

d. Slide-rule method.—Different methods are required when the angle of elevation is equal to or less than 45° and when the angle of elevation is greater than 45°.

(1) *Angle of elevation 45° or less.*—If the angle of elevation e is 45°

or less, the horizontal distance of the pilot balloon is computed by dividing the height h by the tangent of the angle of elevation. This division is accomplished by setting the indicator at the value of the height of the balloon on the D scale, and then moving the T (tangent) scale so that the value of the elevation angle on the T scale coincides with the indicator. Next move the indicator to that end of the T (tangent) scale which is in the slide rule. The horizontal distance of the balloon is given by the reading of the D scale at the indicator.

(2) *Angle of elevation greater than 45°.*—When the angle of elevation is greater than 45°, the triangle must be solved differently because the tangents of angles greater than 45° do not appear directly on the slide rule. The triangle to be solved is:

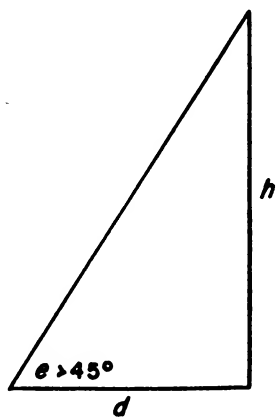


FIGURE 138.—Pilot-balloon triangle (elevation angle>45°).

where e is the angle of elevation and $90-e$ is the complement of the angle of elevation

$$\tan (90-e)=d/h$$
$$d=h \tan (90-e)$$

To determine the horizontal distance of the balloon, it is necessary to multiply the height of the balloon by the tangent of the complement of the angle of elevation. This multiplication is accomplished by setting the slide of the slide rule so that one end of the T (tangent) scale coincides with the value of the height on the D scale. Next set the indicator on the complement of the angle of elevation on the T (tangent) scale. The horizontal distance d is then read at the indicator on the D scale.

56. Plotting horizontal projection.—*a.* The horizontal projection of the position of the pilot balloon is plotted on the plotting board ML-55 by—

(1) Setting the brass rule ML-63 so that its direction, as indicated by the protractor reading at the edge that passes through the center peg of the board, is equal to the azimuth angle.

(2) Finding the horizontal distance from the center, along the same edge of the brass rule, corresponding to the horizontal distance of the pilot balloon from the observation point.

(3) Marking the horizontal projection by placing a small dot on the lacquered surface of the plotting board at the exact distance *d* as indicated along the graduated brass scale ML-63. Move the brass scale to one side, draw a small circle, about one-eighth inch in diameter, about the point, and number the circle to correspond to the numbered minute of the observation. These markings on the plotting board should be made in ink with a pen with a rounded point.

b. The horizontal projection of the balloon's position is plotted in this manner for each minute of the observation. If the horizontal distance of the balloon becomes greater than 15,000 yards, and is thus too far from the origin to be plotted on the board on the regular scale, the projections are plotted at points corresponding to half the actual distances. When the speeds are subsequently determined, the speed values taken from the projection, where the distances plotted are one-half the actual distances, are doubled. If halving the horizontal distance does not permit all of the observed positions to be plotted, the horizontal distance may be divided by a number larger than 2 before plotting the horizontal projections of the balloon's successive positions. The wind speed directly derived from the plot must, of course, be multiplied by the same number to determine the actual wind speed.

57. Determining wind direction.—*a. At the surface.*—The surface-wind direction is obtained from the 10-second azimuth-angle reading. If the azimuth angle is greater than 180°, subtract 180° from it; if the azimuth angle is less than 180°, add 180° to it. The resulting figure is the direction of the wind in degrees. To obtain the direction of the wind on the 36-point scale, divide the direction in degrees by 10. To obtain the wind direction on the 64-point scale, multiply the wind direction in degrees by .178.

b. For any minute except the last minute.—For purposes of computation, the wind direction at the end of any minute of the pilot-balloon observation, except the last minute, is the average wind direction in

the 2-minute period from the beginning of the previous minute to the end of the succeeding minute. Thus, the wind direction for, say, the end of the fourth minute would be the direction of the third-minute position from the fifth-minute position because the wind direction is the direction *from* which the balloon is moving.

(1) *On the 36-point direction scale.*—(*a*) When the wind direction is required on the 36-point scale, scale type ML–137 is used. In determining the wind direction for the first minute, lay scale ML–137 on the plotting board so that the center of the protractor of the scale is at the center peg of the plotting board, and the lines running the length of the scale are parallel to the north-south lines of the plotting board. Determine between which two adjacent radiating lines of the protractor the projection of the second-minute position lies. If the second-minute position is to the right of the center (east of it), the wind direction at the end of the first minute is given by the value between the two adjacent lines that is nearer the center of the protractor, i. e., the larger number. If the second-minute position is to the left (west) of the center peg, the direction is given by the outer (the smaller) of the two numbers between the adjacent radiating lines. If the second point is too far from the center peg to lie within the protractor of the scale, a line may be drawn from the center peg to the second point.

(*b*) For any other minute, say the seventh, the direction of the wind is obtained by laying the scale on the plotting board so that the center of the protractor of the scale lies on the sixth-minute position and the lines along the length of the scale are parallel to the north-south lines of the plotting board. Determine between which two adjacent radiating lines of the protractor the position of the balloon at the eighth minute is indicated. If the eighth point is east of the sixth point, the inner (larger) of the two numbers between these lines is the direction of the wind at the end of the seventh minute; if the eighth point is west of the sixth point, the outer (smaller) of the two numbers between these lines is the direction of the wind. The scale is so constructed as to give the wind direction, which is the direction *from* which the balloon is moving.

(2) *On the 64-point direction scale.*—When the wind direction is required on the 64-point scale, scale type ML–87 is used. In determining the wind direction for any minute, lay the scale ML–87 on the plotting board so that the center of the scale's protractor is on the balloon's position for the previous minute, and the lines running the length of the scale are parallel to the north-south lines of the plotting

board. Determine to which of the radiating lines of the protractor the point second from that at the center lies nearest. If this point is to the right (east) of the point at the center, the wind direction is given by the inner (larger) of the two numbers for the line selected; if this point is to the left (west) of the point at the center of the protractor's scale, the outer (smaller) of the two numbers on the selected line indicates the wind direction. If the second point is out of the range of the protractor of scale ML-87, the wind direction may be determined by connecting the alternate points of the plot by straight lines.

c. For the last minute.—The wind direction for the end of the last minute of the pilot-balloon observation is taken as the average wind direction during the last minute. The scale is placed on the plotting board with the center of the protractor at the next to the last minute so that the lines along the length of the scale are parallel to the north-south lines of the plotting board. The direction of the wind is determined from the relative position of the last position of the balloon in the same manner as from the second following position in the case of previous minutes. This applies equally in the cases of the 36-point scale and the 64-point scale.

58. Determining wind speed.—*a. At the surface.*—Where an anemometer is available, the wind speed is taken directly from the anemometer. Where no anemometer is available, the surface-wind speed is determined from the 10-second reading of the elevation angle. The computation consists of determining the number of yards the balloon would travel in 1 minute at the rate observed in the first 10 seconds, and converting this speed to miles per hour by multiplying by 0.034. Thus, one need only find the horizontal distance that would separate the balloon from the theodolite at 1 minute if the balloon then had an angle of elevation equal to the 10-second reading. This horizontal distance may be determined by any of the several methods already described. Multiplying by 0.034 produces the speed at the surface in miles per hour. For example, the 10-second reading of the angle of elevation is 25.7°. Determine the surface-wind speed if the balloon has the standard rate of rise. The horizontal distance at one minute when the angle of elevation is 25.7° is 500 yards. The surface wind speed is 500 (0.034) = 17 miles per hour.

b. For any minute except the last minute.—(1) For purposes of computation, the wind speed at the end of any minute except the last minute, is the average wind speed during the 2-minute period from the beginning of the previous minute to the end of the succeeding minute. Thus, the wind speed for the end of the fifth minute would

be the average speed during the fifth and sixth minutes. This could be obtained by finding the distance in miles between the balloon's horizontal projections for the end of the fourth minute and the end of the sixth minute, and multiplying that distance by 30 to obtain the speed in miles per hour. (Miles /2 min×30=miles/hour.)

(2) In practice, the computation is accomplished by using the speed scale B of ML-87 or ML-137. Measurement of the speed for any minute consists of placing the scale on the plotting board so that the scale-B edge connects the horizontal projection of the position at the end of the previous minute with the horizontal projection of the succeeding minute's position, the zero of the scale being on the point for the previous minute. The number on the speed scale opposite the projection of the position for the succeeding minute gives the speed for the height represented by the intermediate point in miles per hour.

In cases where, due to rapid movement or distance of the balloon, the horizontal distances are divided by two before the profections are plotted, scale A is used in exactly the same manner as described for scale B; otherwise scale B may be used and the speed obtained multiplied by two. If the horizontal distance has previously been divided by any other number, the speed must be obtained from scale B and multiplied by that number.

c. For the last minute.—The wind speed for the end of the last minute is taken from the average speed during the last minute. It is obtained by measuring the distance between the last two points of the plot, by means of scale A of ML-87 or ML-137, and using the value indicated by scale A as the speed in miles per hour. If the horizontal distances have been divided by any number before plotting the horizontal projections, the speeds obtained from scale A must be multiplied by the same number to obtain the true speed.

59. Determining wind at any altitude.—The wind direction and speed at the end of each minute are those prevailing at the altitude of the balloon at that time. Thus, from the observation of a balloon of standard rate of ascent, the wind at 1,900 yards is the wind computed for the ninth minute. To determine the wind at any intermediate level, interpolation is necessary. Interpolation is accomplished separately for the direction and speed.

***Example*:** Required—the wind at 2,830 yards.

Altitude	Direction	Speed
2700	14	7
(2830)		
2900	19	24

Wind direction: The following proportion is set up:

$$\frac{2830-2700}{2900-2700}=\frac{x}{19-14} \text{ or } \frac{130}{200}=\frac{x}{5}$$

$$x=3.25 \text{ or } 3$$

The wind direction at 2,830 yards is 14+3, or 17.
Wind speed: The following proportion is set up:

$$\frac{2830-2700}{2900-2700}=\frac{x}{24-7} \text{ or } \frac{130}{200}=\frac{x}{17}$$

$$x=11.05 \text{ or } 11$$

The wind speed at 2,830 yards is 7+11, or 18 miles per hour.

SECTION IV

WEATHER CODES

Paragraph

60. Winds-aloft code.—*a. General.*—Pilot-balloon observations of upper-wind directions and velocities are made 4 times daily at approximately 130 strategic locations in the continental United States by the U. S. Weather Bureau and by the U. S. military services. These observations are made at approximately 5 AM, 11 AM, 5 PM, 11 PM, 75th-meridian time (0500, 1100, 1700, and 2300, eastern standard time), and with certain exceptions are transmitted in code four times daily over the Civil Aeronuatics Administration national teletype circuits in regular, designated sequences. In addition to the stations mentioned above, the Weather Bureau and others also make pilot-balloon observations in Alaska, Canada, Puerto Rico, Swan Island, Canal Zone, Cuba, Mexico, Central America, Hawaii, certain Pacific islands, and on vessel stations at sea.

b. Description of code.—(1) All pilot-balloon observations are reported by means of a numerical code in which the direction and velocity of the winds at specified altitudes are given by individual groups composed of four or five figures each. The figures within a group, and the groups within a message, are always arranged in a

specified order which facilitates coding and decoding of the observed data.

(2) Complete reports consist of the following: station designator, time of observation, surface-wind data, and wind data for standard levels above sea level.

(3) Arranged in symbol form, the order of the symbols in a group, and of the groups in a complete message for a land station, is as follows: $I_1I_1I_1G_1G_1$ (or $I_1I_1G_1G_1$) H_aDDvv $DDvv$ H_aDDvv $DDvv$ . . . H_aDDvv H_aDDvv H_aDDvv . . . This order is used when the station's elevation lies from 200 feet below an *even* standard level (including sea level) to 200 feet below the next higher *odd* standard level.

(4) When the station's elevation lies from 200 feet below an *odd* standard level to 200 feet below the next higher *even* standard level, the order of the symbols and groups is as follows: $I_1I_1I_1$ G_1G_1 (or $I_1I_1G_1G_1$) H_aDDvv H_aDDvv $DDvv$ H_aDDvv $DDvv$ . . . H_aDDvv H_aDDvv H_aDDvv . . .

(*a*) $I_1I_1I_1$ (or I_1I_1).—Station designator. It consists of two or three letters which are the regular Civil Aeronautics Administration call letters for the station at which the observation was taken. Examples: OA for Oakland, PEV for Ely.

(*b*) G_1G_1—Time the observation was taken. This is always coded as two figures representing the nearest whole hour, 75th-meridian time (Eastern Standard Time), on a 24-hour-clock basis. (Observations taken at ship stations, however, are coded using Greenwich civil time on a 24-hour-clock basis.) In order that the approximate mean time of the observation may be coded, 20 minutes are added to the time when the balloon was actually released, and this new time is used for all coding and transmission purposes. However, if the total length of the observation is less than 20 minutes, only the actual number of minutes of the observation will be added to the time of the balloon's release, instead of the 20 minutes otherwise added. Example: Denver, Colo., balloon released at 2:12 PM, 105th-meridian time; adding 20 minutes, the time used for coding is 2:32 PM; the nearest whole hour is 3 PM, or 5 PM, 75th-meridian time (Eastern Standard Time). This is 1700 on the 24-hour-clock basis, and accordingly the figure "17" is used for G_1G_1. However, if the balloon was observed for only 14 minutes, the new time used would be 2:26 PM (4:26 Eastern Standard Time), the nearest whole hour would be 4:00 Eastern Standard Time, and the code figures for G_1G_1 would be "16."

(*c*) H_a—Altitude of standard level. The presence or absence of specific, identifying code figures is used to identify the particular

levels for which data are coded. The figures for code symbol H_a are always used to identify the particular standard levels listed below:

H_a	Level
0	Surface; 10,000; 20,000; 30,000 feet, etc.
2	2,000; 12,000 feet.
4	4,000; 14,000 feet.
5	25,000; 35,000; 45,000 feet, etc.
6	6,000 feet.
8	8,000 feet.

Identifying code figures are never used to identify the following standard levels: 1,000; 3,000; 5,000; 7,000; 9,000; 11,000; 13,000; 15,000 feet. Wind directions and velocities for levels which are not standard levels are never sent. Standard levels occur at 1,000-foot intervals from sea-level up to and including 15,000 feet. Above 15,000 feet the standard levels occur at 5,000-foot intervals (20,000; 25,000; 30,000; 35,000 feet, etc.). When the altitude of a station is less than 200 feet below a particular standard level, the wind data for that particular standard level will be omitted from the coded report, but data for all higher standard levels will be included. For example, where the elevation of the theodolite platform is 1,820 feet above sea level, it is less than 200 feet from the 2,000-foot standard level, and, accordingly, the first standard level above the surface for which wind data are coded is the 3,000-foot level and not the 2,000 foot level. However, if the elevation of the theodolite platform at a station is exactly 1,800 feet (or below 1,800 feet) the observed wind data for the 2,000-foot standard level will be included in the coded report. Obviously, a coded report should not have wind data for standard levels below the elevation of a station, nor data for standard levels above the observed ascent of the balloon. However, when the maximum observed altitude of a balloon ascent is only a short and specified distance below a standard level, the data observed at this maximum altitude, for coding purposes, are presumed to exist also at the next higher standard level, and are coded as though they were actually observed at the next higher standard level. Whenever the maximum observed altitude is 300 feet, or less, below any standard level up to and including 15,000 feet, the data for such maximum altitude will be coded for the next higher standard level. Whenever the maximum observed altitude is 1,000 feet, or less, below any standard level above 15,000 feet, the data for such maximum altitude will be coded for the next higher standard level. When the maximum altitude observed is more than 300 feet below any standard level up to and including

15,000 feet, or is more than 1,000 feet below any standard level above 15,000 feet, the final group in a message will be the data observed at the standard level immediately below the maximum observed altitude, and a separate group for the maximum altitude data will not be sent.

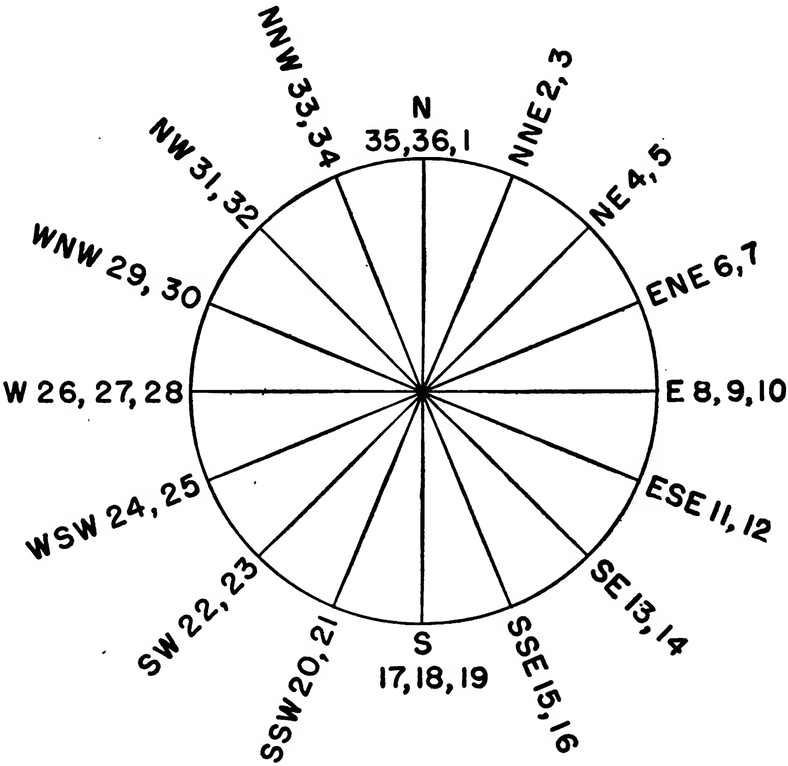
(*d*) DD—Wind direction, which is always coded by two figures. The true wind direction is coded to 36 points, in which 09 is an east wind, 18 is a south wind, 27 is a west wind, and 36 is a north wind. Calm is coded by "00." The actual direction from which the wind is blowing, expressed in degrees, is divided by 10 and then coded to the nearest whole number, in accordance with the usual rule wherein the nearest even number is used when the decimal is exactly five-tenths. Examples: 76°=7.6, or 08; 125°=12.5, or 12; 353°=35.3, or 35. A table covering all wind directions is given below. As explained in the next paragraph, the coded value for DD is increased by 50 whenever the coded velocity is 100 or more miles per hour.

1. Direction code.

Code figure	Direction in degrees	Code figure	Direction in degrees
00	Calm	19	186–194
01	6– 14	20	195–205
02	15– 25	21	206–214
03	26– 34	22	215–225
04	35– 45	23	226–234
05	46– 54	24	235–245
06	55– 65	25	246–254
07	66– 74	26	255–265
08	75– 85	27	266–274
09	86– 94	28	275–285
10	95–105	29	286–294
11	106–114	30	295–305
12	115–125	31	306–314
13	126–134	32	315–325
14	135–145	33	326–334
15	146–154	34	335–345
16	155–165	35	346–354
17	166–174	36	355– 5
18	175–185		

2. A simple method whereby a decoder may convert the coded figures into points of the compass, N., NNE., E., is illustrated by the diagram below:

36 POINT SCALE FOR WIND-ALOFT CHARTS



(*e*) vv—Wind velocity in miles per hour. This is always coded by two figures.

1. For observed wind velocities up to 99 miles per hour, the actual velocities are coded, using two figures (01, 02, 03, . . . 99). The code figures "00" are used when there is no velocity (calm), i. e., when the velocity is less than 1 mile per hour. Whenever the velocity is coded as "00" the direction is always coded as "00" also.

2. For observed wind velocities of 100 to 199 miles per hour, the actual velocity is reduced by 100 and the remainder coded for vv. The true velocity is indicated in the coded report by adding 50 to the number representing true wind direction and coding the sum for symbol DD. Example: A wind direction of 260° and velocity of 94

miles per hour at 8,000 feet is coded as "82694"; but if the velocity is 104 miles per hour, it is coded as "87604."

3. For observed wind velocities of 200 miles per hour or more, the actual velocity is reduced by 200 and the remainder coded for symbol vv. The true velocity is indicated by inserting a slant between the coded figures used for DD and vv. As in the case for velocities of 100 to 199 miles per hour, 50 is added to the number representing true wind direction and the sum is coded for symbol DD. Example: A true wind of 280° with velocity at 214 miles per hour, occurring at 14,000 feet, is coded as "478/14".

(4) The order of symbols within a group, and of groups within a pilot-balloon message from a ship station, is as follows: YQLLL lllGG DDvv DDvv . . . DDvv DDvv . . .

(*a*) The same procedure is followed in coding and decoding the symbols DD and vv as for a land station.

(*b*)

Symbol	*Data*
Y	Day of week (Greenwich civil time).
Q	Octant of globe.
LLL	Latitude in degrees and tenths. (The tenths are obtained by dividing the number of minutes by 6 and neglecting the remainder.)
lll	Longitude in degrees and tenths. (The tenths are obtained as for LLL.)
GG	Greenwich civil time of observation on a 24-hour-clock basis.

NOTE.—A more complete definition of Y, Q, LLL, lll, and GG may be obtained by referring to the paragraph on decoding map reports from ships at sea.

(5) Some examples of representative reports are given below:

(*a*)

Observed data	*Coded*
Station—Cheyenne (6,133 feet above sea level)	CX
Time—3:02 p. m., 105th-meridian time	17
Surface—163°, 8 mph	01608
7,000 feet—172°, 14 mph	1714
8,000 feet—175°, 16 mph	81816
9,000 feet—185°, 20 mph	1820
10,000 feet—195°, 22 mph	02022
11,000 feet—214°, 20 mph	2120
12,000 feet—235°, 17 mph	22417
12,720 feet—248°, 29 mph	2529

Complete coded report: CX17 01608 1714 81816 1820 02022 2120 22417 2529.

(*b*)

Observed data	*Coded*
Station—Kylertown (1,688 feet above sea level)	KY
Time—10:40 a. m., 75th-meridian time	11
Surface—230°, 18 mph	02318
2,000 feet—265°, 25 mph	22625
3,000 feet—272°, 28 mph	2728
4,000 feet—275°, 32 mph	42832
5,000 feet—282°, 44 mph	2844
6,000 feet—285°, 52 mph	62852
7,000 feet—288°, 67 mph	2967
8,000 feet—295°, 78 mph	83078
9,000 feet—304°, 87 mph	3087
10,000 feet—306°, 94 mph	03194
11,000 feet—315°, 102 mph	8202
12,000 feet—322°, 108 mph	28208
13,000 feet—326°, 111 mph	8311
14,000 feet—327°, 114 mph	48314
15,000 feet—329°, 117 mph	8317
20,000 feet—332°, 126 mph	0836
25,000 feet—337°, 129 mph	58429
28,051 feet—340°, 131 mph	

Complete coded report: KY11 02318 22625 2728 42832 2844 62852 2967 83078 3087 03194 8202 28208 8311 48314 8317 08326 58429.

(6) In case an observation is not made or not received at the point of transmission prior to the time of filing the report, a "no observation" report is filed, consisting of the following:

(*a*) Station designator.

(*b*) Time, on a 24-hour clock, EST. (Ship stations will use Greenwich civil time.)

(*c*) Reason for no observation, using one of the following words:

P1BA—No balloons.
P1CO—Low clouds.
P1DU—Thick dust.
P1F1—Not filed.
P1FO—Foggy.
P1HE—No gas.
P1IO—Instrument trouble.
P1KO—Smoky.
P1RA—Raining.
P1SE—Unfavorable sea conditions.
P1SO—Snowing.
P1W1—High or gusty surface wind.

Example: "CX05 P1CO" would indicate that no pilot-balloon observation was made at Cheyenne for 5:00 AM, EST, due to low clouds.

61. Code for radiosonde (raob) and airplane (apob) weather observations.—*a. General.*—The code that is described in succeeding paragraphs will apply to raob and apob messages transmitted by teletype, telegraph, or radio.

b. Description of code.—(1) *Order of data.*—The data generally to be coded in raob messages from land stations and the order in which they are to be grouped are shown in symbolic form below:

II(I)(Y_1)G_1G_1 HHPPT TUUmm HHPPT TUUmm . . . (for surface and successive significant levels as required).

$P_aP_aP_bP_b$ $P_cP_cP_dP_d$ $P_eP_eP_fP_fP_gP_g$ (for pressures at designated levels).

$P_1P_1P_2P_2h_p$ N_cCdd $P_1P_1P_2P_2h_p$ N_cCdd . . . (for cloud types or layers from none to three layers, as required).

$w_3P_3P_3P_4P_4$ $w_3P_3P_3P_4P_4$ (for special phenomena as required).

$\psi_x\psi_x\psi_y\psi_y\psi_s\psi_s$ $P_xP_xP_{sx}P_{sx}\theta_x$ $\theta_xP_yP_yP_{sy}P_{sy}$ $P_sP_sP_{ss}P_{ss}$ $D_1D_1S_1S_1D_2D_2$ $S_2S_2D_3D_3S_3S_3$ (for isentropic data, as required).

$w_4H_1H_1H_2H_2$ $w_4H_1H_1H_2H_2$ (for icing, as required).

MMMM (for termination of observations).

(*a*) Groups $P_1P_1P_2P_2h_p$ are included in raobs for those cases where appropriate values of P_1P_1 are obtained by observational means (for example, by use of ceiling light projector or ceiling balloon).

(*b*) Whenever any of the phenomena represented by the symbol w_3 occur at the surface and the upper limit is unknown, the data for P_3P_3 will be the surface pressure and slants will be used for the missing data P_4P_4.

(2) *Code form for raobs from ships.*—The code form for raobs from ships is identical with that for land stations except that the first group II(I)(Y_1) G_1G_1 is replaced by the word RAOB and the two numeral groups YQLLL lllGG which are taken from the International Ship Code.

(3) *Code form for apobs.*—The code form for apobs is the same as for raobs except that groups $P_1P_1P_2P_2H_p$ are free from restrictions and that groups $W_4H_1H_1H_2H_2$ are inapplicable.

(4) *Explanation of symbols.*

Symbol	*Data*
II(I)	Station call letters, ordinarily two in number, used in transmission by teletype, telegraph, and point-to-point radio communication. (In major weather bulletins broadcast from the Naval Radio Stations at Washington, D. C. (NAA/NSS) and San Francisco, Calif. (NPG), the names of the observation stations spelled out — omitting the State or Territory — are used in lieu of call letters.)

Symbol	*Data*
(Y_1)	Day of the week on which the observation was made: 1 = Sunday, 2 = Monday, etc., 7 = Saturday. (See code table 36.) The day will be reckoned according to 75th-meridian time; for example, Thursday = 5 will signify the period extending from 0001 to 2400 hours, Thursday, 75th-meridian time. This code datum (Y_1) is to be included in the message only if the message is filed for transmission after the last scheduled period for raobs-apobs in the National Communication Schedule (teletype) of the Civil Aeronautics Administration for the day on which the observation is made.
G_1G_1	Time of launching (or take-off) to the nearest whole hour, 75th-meridian time, on the 00–23 hour basis, e. g., 01 designates 1 a. m.; 13 designates 1 p. m.
Y	Day of the week on which observation was made: 1 = Sunday, 2 = Monday, etc., 7 = Saturday. The day will be reckoned according to Greenwich mean time; for example, Thursday = 5 will signify the period extending from 0001 to 2400 hours, Thursday, Greenwich mean time. (For use only with ship-station raobs, but not with land-station raobs.)
Q	Octant of the globe. (See code table 37.)
LLL	Latitude in degrees and tenths, the tenths being obtained by dividing the number of minutes by 6 and neglecting the remainder.
lll	Longitude in degrees and tenths, the tenths being obtained as for latitude LLL.
GG	Time of launching to the nearest whole hour, Greenwich mean time (00 designating midnight, 12 being noon, and 18 being 6:00 p. m.). (For use only with ship-station raobs, but not with land-station raobs.)
HH	Height above sea level in hundreds of meters, to the nearest whole hundred, omitting the 10,000-place digit wherever involved; e. g., 520 m. is transmitted as 05, 4,570 m. is transmitted as 46, and 12,520 m. as 25. Fifties (50′) are disposed of according to the rule for changing to the nearest even hundred; e. g., 2,350 m. is transmitted as 24, 2,450 m. is transmitted as 24, and 12,450 m. also as 24.
PP	Barometric pressure, in whole millibars, including only tens and units digits, i. e., with hundreds and thousands digits omitted. For example: 1,020 mb. is transmitted as 20; 1,000 mb. as 00, 982 mb. as 82,900 mb. as 00, 705 mb. as 05, etc. (Note code tables 9 and 10 regarding average relation of pressure to altitude.)
TT	Temperature of the air in whole degrees centigrade. A naught will be used for the tens digit when the temperature is 0° C. to 9° C., inclusive. When the temperature is −1° C. or lower, the minus sign will be disregarded and 50 added for coding. Where the sum of the temperature and 50 in these cases is 100 or more, the hundreds digit will be omitted. For example:

Symbol	*Data*
	15° C. is transmitted as 15. 5° C. is transmitted as 05. 0° C. is transmitted as 00. SUMS (When temperatures are negative.) −1° C. (1+50=51) is transmitted as 51. −45° C. (45+50=95) is transmitted as 95. −50° C. (50+50=100) is transmitted as 00. −55° C. (55+50=105) is transmitted as 05. −65° C. (65+50=115) is transmitted as 15. (In transmission, the TT digits are split between the end of the first group and the beginning of the second group for each significant level.)
UU	Relative humidity in whole percent. A naught will be used for the tens digit when the relative humidity is 0 to 9 percent, inclusive. Zero and 1 percent will be coded as 01, 9 percent as 09, 50 percent as 50, 100 percent as 00.
mm	Mixing ratios in grams of water vapor per kilogram of dry air, omitting the tens digit, coding only the units and tenths digits. Examples: 8.7 g./Kg. as 87. NOTE.—Code table 11 giving saturation mixing ratios for various temperatures and pressures. The saturation mixing ratio multiplied by the relative humidity expressed decimally gives a very close approximation to the actual mixing ratio. It is thus possible to ascertain quickly the value of the missing tens figure if not already known.
P_aP_a	Barometric pressure, in whole millibars, at 1,520 meters (5,000 feet) m. s. l., omitting the hundreds digit, coding only the tens and units digits. The pressure at 1,520 m., m. s. l., will usually lie in the range 810 to 880 mb. Examples: 833 mb. will be coded as 33; 851 mb. as 51, etc.
P_bP_b	Barometric pressure, in whole millibars, at 3,050 meters (10,000 feet) m. s. l., omitting the hundreds digit, coding only the tens and units digits. The pressure at 3,050 m., m. s. l., will usually lie in the range 640 to 730 mb. Examples: 670 mb. will be coded as 70; 695 mb. as 95; 716 mb. as 16.
P_cP_c	Barometric pressure, in whole millibars, at 4,570 meters (15,000 feet) m. s. l., omitting the hundreds digit, coding only the tens and units digits. The pressure at 4,570 m., m. s. l., will usually lie in the range 510 to 610 mb. Examples: 540 mb. will be coded as 40; 585 mb. as 85.
P_dP_d	Barometric pressure, in whole millibars, at 6,100 meters (20,000 feet) m. s. l., omitting the hundreds digit, coding only the tens and units digits. The pressure at 6,100 m., m. s. l., will usually lie in the range 410 to 510 mb. Examples: 464 mb. will be coded as 64; 481 mb. as 81.
P_eP_e	Barometric pressure, in whole millibars, at 10,000 meters (32,810 feet) m. s. l., omitting the hundreds digit, coding only the tens

Symbol	*Data*
	and units digits. The pressure at 10,000 m., m. s. l., will usually lie in the range 210 to 310 mb. Example: 251 mb. will be coded as 51.
P_fP_f	Barometric pressure, in whole millibars, at 13,000 meters (42,650 feet) m. s. l., omitting the hundreds digit, coding only the tens and units digits. The pressure at 13,000 m., m. s. l., will usually lie in the range 115 to 215 mb. Example: 154 mb. will be coded as 54.
P_gP_g	Barometric pressure, in whole millibars, at 16,000 meters (52,490 feet) m. s. l., omitting the hundreds digit (whenever it occurs), coding only the tens and units digits. The pressure at 16,000 m., m. s. l., will usually lie in the range 55 to 155 mb. Example: 103 mb. will be coded as 03.
P_1P_1	Barometric pressure, in tens of millibars, corresponding to the height of the base of the cloud designated by the code figure for C in the immediately succeeding group. The thousands digit is to be dropped when the pressure is 1,000 mb. or greater. For example, 1,020 mb. will be coded as 02, 875 mb. as 88, etc.. the units digit being disposed of according to the standard rule for dropping decimals. When the pressure in question is unknown, P_1P_1 will be coded in apobs in accordance with code table 1.
P_2P_2	Barometric pressure, in tens of millibars, corresponding to the height of the top of the cloud designated by the code figure for C in the immediately succeeding group. The rules for coding observed or estimated data are the same as those for P_1P_1. When the pressure in question is unknown, P_2P_2 will be coded in apobs in accordance with code table 1.
h_D	A characteristic numeral, coded according to code table 2, to indicate whether the pressures (P_1P_1 and P_2P_2) corresponding to the height of the base and top, respectively, of the cloud type designated by the code figure for C in the succeeding group, have been ascertained by observation, have been estimated, or are unknown.
N_e	Amount, in tenths, of sky covered by clouds of the type designated by the code figure for C which immediately follows in the group and which represents clouds at a given height. (See the immediately preceding group in code.) Ten-tenths will be coded as 0, "few" and one-tenth will be coded as 1, and amounts from two-tenths to nine-tenths will be coded by the figures 2 to 9, respectively.
C	Type of cloud. (See code table 33.)
dd	Direction from which the clouds are coming, according to a scale 01–36, i. e., the number of degrees measured from north divided by 10 and rounded off to the nearest whole figure. Calm=00, N=36, E=09, S=18, W=27, etc.

NOTE.—A pair of groups $P_1P_1P_2P_2h_D$ N_eCdd will be used for each type or layer of cloud to a maximum of three for which data may be appropriately transmitted in the message (see next

Symbol	*Data*
	sentence), except that groups $P_1P_1P_2P_2h_p$ are omitted when observational data therefor are unavailable in raobs. As many as three cloud groups may be included in the message, representing low, intermediate, and high clouds, respectively. If no cloud form in any of these categories is observed, the corresponding groups $P_1P_1P_2P_2h_p$ N_oCdd are omitted.
w_3	A characteristic numeral designating the nature of a phenomenon occurring at the surface, or encountered aloft by an airplane flying in the vicinity, coded in accordance with code table 3.
P_3P_3	Barometric pressure, in tens of millibars, at the level of entry of an ascending airplane into the phenomenon given by the code figure for w_3. The rules for coding observed data are the same as those for P_1P_1. When the pressure in question is unknown, P_3P_3 will be coded in accordance with code table 5 in apobs and by slants in raobs.
P_4P_4	Barometric pressure, in tens of millibars, at the level of emergence of an ascending airplane from the phenomenon given by the code figure for w_3. The rules for coding observed data are the same as those for P_1P_1. When the pressure in question is unknown or there was no emergence from the phenomenon during the ascent, P_4P_4 will be coded in accordance with code table 5 in apobs and by slants in raobs. NOTE.—One $w_3P_3P_3P_4P_4$ group will be used to indicate each of the w_3 phenomena observed. The phenomena will be indicated in the message in the order of increasing value of w_3, that is, in the order: rime or frost, hard ice, haze or smoke, etc. (See code table 3.) Data for successive layers in which rime or frost formed will be given before data for layers in which hard ice formed, etc., and data for successive turbulent layers will be given after data for a thunderstorm heard at the station.
$\psi_x\psi_x$	The last two digits of the stream function corresponding to the potential temperature specified by $\theta_x\theta_x$.
$\psi_y\psi_y$	The last two digits of the stream function corresponding to the potential temperature 6° A. higher than the potential temperature specified by $\theta_x\theta_x$.
$\psi_z\psi_z$	The last two digits of the stream function corresponding to the potential temperature 12° A. higher than the potential temperature specified by $\theta_x\theta_x$.
P_xP_x	Actual pressure, in tens of millibars, with the thousands digit omitted, corresponding to the potential temperature indicated by $\theta_x\theta_x$.
$P_{sx}P_{sx}$	Condensation pressure, in tens of millibars, with the thousands digit omitted, corresponding to the potential temperature indicated by $\theta_x\theta_x$.
$\theta_x\theta_x$	A potential temperature in degrees A., the hundreds digit being omitted, for which stream function and pressure data designated by the symbols $\psi_x\psi_x$, P_xP_x, $P_{sx}P_{sx}$ are transmitted. For example, a potential temperature of 308° A. is coded as 08, 296° A. is coded as 96.

Symbol	*Data*
P_yP_y	Actual pressure, in tens of millibars, with the thousands digit omitted, corresponding to the potential temperature which is 6° A. higher than that specified by $\theta_x\theta_x$.
$P_{sy}P_{sy}$	Condensation pressure, in tens of millibars, with the thousands digit omitted, corresponding to the potential temperature which is 6° A. higher than that specified by $\theta_x\theta_x$.
P_zP_z	Actual pressure, in tens of millibars, with the thousands digit omitted, corresponding to the potential temperature which is 12° A. higher than that specified by $\theta_x\theta_x$.
$P_{sz}P_{sz}$	Condensation pressure, in tens of millibars, with the thousands digit omitted, corresponding to the potential temperature which is 12° A. higher than that specified by $\theta_x\theta_x$. NOTE.—P_xP_x, $P_{sx}P_{sx}$, P_yP_y, $P_{sy}P_{sy}$, P_zP_z, and $P_{sz}P_{sz}$ are coded in the same manner as P_1P_1. See examples thereunder.
D_1D_1	Direction of the shear-stability ratio vector as measured from the N. through the E., S., and W., at the height of the lowest specified potential temperature surface for which other isentropic data are computed and transmitted, and coded to 36 points in accordance with code table 12.
D_2D_2	Direction of the shear-stability ratio vector as measured from the N. through the E., S., and W., at the height of the specified intermediate potential-temperature surface for which other isentropic data are computed and transmitted, and coded to 36 points in accordance with code table 12.
D_3D_3	Direction of the shear-stability ratio vector as measured from the N. through the E., S., and W., at the height of the highest specified potential-temperature surface for which other isentropic data are computed and transmitted, and coded to 36 points in accordance with code table 12.
S_1S_1	Magnitude of the shear-stability ratio vector in decameters per second at the height of the lowest specified potential-temperature surface for which other isentropic data are computed and transmitted, rounded off to the nearest corresponding number occurring in the "Magnitude in decameters per second" column of code table 13. NOTE.—The magnitude of the shear-stability ratio vector has the dimensions of velocity, and is here expressed in terms of the unit decameters per second. The appropriate code numbers from code table 13 are transmitted for S_1S_1, S_2S_2, and S_3S_3, respectively.
S_2S_2	Magnitude of the shear-stability ratio vector in decameters per second at the height of the specified intermediate potential-temperature surface for which other isentropic data are computed and transmitted, rounded off to the nearest corresponding number occurring in the "Magnitude in decameters per second" column of code table 13.
S_3S_3	Magnitude of the shear-stability ratio vector in decameters per second at the height of the highest specified potential-temperature surface for which other isentropic data are computed and transmitted, rounded off to the nearest corresponding number

Symbo	Data
	occurring in the "Magnitude in decameters per second" column of code table 13.
W_4	A characteristic numeral from 1 to 3, inclusive, designating the nature of the phenomenon being coded in accordance with code table 4 for raobs.
H_1H_1	Height of the lower limit of the phenomenon above sea level in hundreds of meters, to the nearest whole hundred, omitting the ten-thousands digit wherever involved.
H_2H_2	Height of the upper limit of the phenomenon above sea level in hundreds of meters, to the nearest whole hundred, omitting the ten-thousands digit wherever involved.
MMMM	A four-letter group to indicate the reason for termination of raobs, the maximum altitudes of which are not more than 6,000 meters, m. s. l., to be used whenever the entire record above that altitude is missing or unusable. (See code table 7.)

(5) *Missing and doubtful data.*—(*a*) Whenever any of the data are missing for groups to be transmitted, a slant is substituted for each missing digit. In the case of radio broadcasts, the letter X is substituted for each missing digit. For exceptions to these rules see P_1P_1, P_2P_2, P_3P_3, P_4P_4.

(*b*) In cases where there is doubt concerning the accuracy of the data for all elements for the entire sounding, the group "DBTF", signifying "doubtful", is transmitted immediately following the "call letters-time" group if the message originates at a land station, or immediately following the "longitude-time" group if it originates at a ship station. If only one or two elements are doubtful for the entire sounding, an appropriate group or groups such as "TMPS", "PRES" or "HMDTY" are inserted preceding the above mentioned "DBTF" group.

(*c*) If there is doubt concerning accuracy of the data for all elements for only a portion of the sounding, the group "DATA" is inserted immediately before the doubtful portion of the record and the group "DBTF" follows immediately the doubtful data. However, if only one or two elements are doubtful for a portion of the sounding, an appropriate group such as "TMPS", "PRES", or "HMDTY" is substituted for the "DATA" group.

(*d*) The following are examples of messages containing doubtful data.

1. When data for the three elements, i. e., temperature, pressure, and relative humidity are doubtful for the entire sounding——$II(I)(Y_1)G_1G_1$ DBTF - - - - - - - - - - etc.

2. When only the humidity data are doubtful for the entire sounding——II(I)(Y_1)G_1G_1 HMDTY DBTF - - - - - - - - - - etc.

3. When data for the three elements are doubtful for only the lower portion of the sounding——II(I)(Y_1)G_1G_1 DATA - - - - - - - - - - - - - - - DBTF - - - - - - - - - - - - - - - - etc.

4. When only the humidity data are doubtful for an intermediate portion of the sounding——II(I)(Y_1)G_1G_1 - - - - - - - - - - - - - - - HMDTY - - - - - - - - - - - - - - - DBTF - - - - - - - - - - etc.

5. When the temperature and pressure data are doubtful for the upper portion of the sounding——II(I)(Y_1)G_1G_1 - TMPS PRES - - - - - - - - - - DBTF.

Note.—When the upper portion of the sounding is doubtful, the group "DBTF" will appear immediately after the data for the last significant level instead of at the end of the message.

6. When the humidity data are doubtful for the lower portion and the temperature data are doubtful for the upper portion of the sounding——II(I)(Y_1)G_1G_1 HMDTY - - - - - - - - - - - - - - - DBTF - - - - - - - - - - - - - - - TMPS - - - - - - - - - - - - - - - DBTF.

(*e*) If there is a gap in the record made by the instrumental recorder for radiosonde or airplane observations, such that it appears possible that there may have been significant levels within the altitudes covered by the gap, the group //9// will be sent between the pairs of five-figure groups which give the data for the two significant levels pertaining to the portion of the record immediately preceding and following the gap. In many cases the group //9// in the message may point to the possibility that one or both of the significant levels just referred to might not have been regarded as significant if the missing data of the gap had been available.

(*f*) Whenever the relative-humidity record is not obtained for any reason, e. g., the occurrence of temperature below —40° C., slant marks are sent in the message in place of the condensation pressure corresponding to the missing humidity.

(6) *"No raob," or "no apob" messages.*—A "no raob" or "no apob" message is one containing no radiosonde or airplane observation data, and indicating the reason for not transmitting those data at or before

the time of filing shown in the message. "No raob" or "no apob" messages are composed of two groups:

(*a*) $II(I)(Y_1)G_1G_1$—where these symbols have meanings similar to the corresponding symbols in a regular message, except that the time of filing the message with the communications office is substituted for observation or take-off time in respect to (Y_1) and G_1G_1. It is understood, of course, that in messages from ship stations, RAOB YQLLL lllGG is substituted for $II(I)(Y_1)G_1G_1$, the latter group being applicable to land stations only.

(*b*) A group from code table 6 consisting of four letters indicative of the reason for the "no raob" or "no apob" message.

(7) *Correction messages.*—(*a*) Messages transmitting corrections to regular raob or apob messages begin with the observation CQN.

(*b*) Correction messages may be of five kinds, as indicated in the paragraphs immediately below. In the following, "n" with a subscript designates the number of the numeral group in the original message to which reference is made, counting $II(I)(Y_1)G_1G_1$ or YQLLL as 1, and the following group as 2, etc.

1. When a complete corrected message is transmitted, the code form is: CQN followed immediately by the corrected message in its entirety.

2. When it is desired to correct specified groups in the original message, the code form is: CQN $II(I)(Y_1)G_1G_1$ $n_1/n_2/n_3/n_4$ -, where the dashes represent the corrected figures of the groups numbered n_1, n_2, n_3, etc., respectively, in the original message. When only one group is to be corrected, the group number in question, n_1, is followed by a slant in the message; e. g., if "n" is group 8, the code form is: CQN $II(I)(Y_1)G_1G_1$ 8/ - - - - -.

3. When it is desired to insert one or more new groups between specified groups in the original message, the code form is: CQN $II(I)(Y_1)G_1G_1$ insrt n_1/n_2 - - - - - n_3/n_4 - - - - -, etc. The abbreviation "insrt" included in the correction message designates the word "insert," and the dashes represent the figures of new groups to be inserted between groups n_1 and n_2, n_3 and n_4, etc., respectively, of the originally transmitted message. When, for example, one new group is to be inserted between groups 5 and 6 of the original message, and two new groups in given order are to be inserted between

groups 13 and 14, the code form is: CQN II(I)(Y_1)G_1G_1 insrt 5/6 \- - - - - 13/14 \- - - - - \- - - - - . If one or more new groups are to be added to the end of the message, the figure represented by the "n" before the last slant in the correction message is the number of the last group of the original message, and no figure immediately follows that slant. (It will be noted that when data are to be inserted, the groups containing the numbers (n's) of the groups which are to be inserted may be distinguished from the groups containing the correct figures by the fact that the "n" groups can have only one slant, not at the beginning, with never more than 2 digits preceding the slant; whereas the correct-figure group either has no slants or the slants appear as two or more, adjacent to each other, or a single slant occurs at the beginning, or a single slant occurs at the end preceded by more than two digits.)

4\. When it is desired both to correct specified groups and to insert one or more new groups between specified groups in the original message, the code form is: CQN II(I)-(Y_1)G_1G_1 $n_1/n_2/n_3$ \- - - - - \- - - - - \- - - - - insrt n_4/n_5 \- - - - - \- - - - - n_6/n_7 \- - - - -, etc. Data between the II(I)(Y_1)G_1G_1 group and abbreviation "insrt" refer to original groups to be corrected, and data after "insrt" refer to new groups to be inserted.

5\. When it is desired to delete a specified group in the original message and not replace it by any other group, this is done by employing slants (/) (or X's in non-point-to-point radio communications) for the group in the correction message, e. g. —— CQN II(I)(Y_1)G_1G_1 n_1/ /////; or, if group n_1 is to be corrected and n_2 deleted —— CQN II(I)(Y_1)G_1G_1 n_1/n_2 \- - - - - /////.

(8) *Suggestions for decoding stream functions.*—(*a*) Stream functions for three specified potential temperatures (the lowest of which appears in the coded report as $\theta_x\theta_x$ with the hundreds digit omitted) are originally computed from the sounding data, and expressed by four digits each; for example, 2,982 millions of ergs/gram for potential temperature 296° Absolute. The first two digits of each computed stream function are, therefore, omitted from the coded message. In decoding, these first two digits must be supplied by the decoder through inspection of the values of potential temperatures pertaining to the data, taking into consideration the fact that the first three digits of the stream function will be very nearly equal in numerical value to the three digits of the potential temperature in whole degrees Absolute. For example, from a transmitted group 823486 and an indication in the message that the lowest potential temperature is 296° Absolute, it may be deduced that the stream function corresponding to that potential temperature is 2,982 millions of ergs/gram, that the stream function corresponding to the potential temperature 6° higher (302° A) is 3,034 millions of ergs/gram, and that the stream function corresponding to the highest potential temperature (308° A) is 3,086 millions of ergs/gram.

(*b*) A convenient formula to be used by the decoder in checking a doubtful stream-function value for a given potential temperature is: $\psi = 10.05\,T + 9.8h$, where ψ is the value of the stream function in millions of ergs/gram, T is the value in whole degrees absolute of the temperature of the air at the particular potential-temperature level for which the stream function is in doubt, and h is the height in hectometers (for example, 2,000 meters would be used in the formula as 20) of the particular potential-temperature level.

(9) *Examples of decoding.*—Examples showing methods of decoding follow:

(*a*) Message received by teletype: BU01 02940 19539 05660 93325 10100 82418 18190 41912 32800 10805 58906 80601 91089 3//// 27780 9//// 44360 9//// 42160 6//// 4903 8073 7170// 1135 823486 79569 67248 6240 224830 423520.

Coded: Code figures		Coded: Code symbols		Decoded					
BU01		IIG_1G_1		Burbank, Calif., raob ascent made at 1 a. m., 75th-meridian time					
				Data for levels					
				Level number	Elevations, m. (m. s. l.)	Barometric pressure (mb.)	Temperature (° C.)	Relative humidity (percent)	Mixing ratio (g./kg.)
02940	19539	HHPPT	TUUmm	Surface	[1] 200	994	1	95	3.[illegible]
05660	93325	HHPPT	TUUmm	1	500	966	9	33	2.[illegible]
10100	82418	HHPPT	TUUmm	2	1,000	910	8	24	1.[illegible]
18190	41912	HHPPT	TUUmm	3	1,800	819	4	19	1.[illegible]
32800	10805	HHPPT	TUUmm	4	3,200	680	1	8	.5
58906	80601	HHPPT	TUUmm	5	5,800	490	−18	6	.1
91089	3////	HHPPT	TUUmm	6	9,100	308	−43	[2]	[2]
27780	9////	HHPPT	TUUmm	7	12,700	178	−59	[2]	[2]
44360	9////	HHPPT	TUUmm	8	14,400	136	−59	[2]	[2]
54160	6////	HHPPT	TUUmm	9	15,400	116	−56	[2]	[2]

Code figures		Code symbols		Decoded
4903	8073	$P_aP_aP_bP_bP_cP_cP_dP_d$		Barometric pressure: 849 mb. at 1,520 m.; 703 mb. at 3,050 m.; 580 mb. at 4,570 m.; 473 mb. at 6,100 m.
7170//		$P_eP_eP_fP_fP_gP_g$		Barometric pressure: 271 mb. at 10,000 m.; 170 mb. at 13,000 m.; Observation yields no pressure datum at 16,000 m.
1135		N_cCDD		Few or 1 Ci direction 350°.
823486		$\psi_x\psi_x\psi_y\psi_y\psi_z\psi_z$		Stream function 2,982 millions of ergs/gram for $\theta=296°$ A. Stream function 3,034 millions of ergs/gram for $\theta=302°$ A. Stream function 3,086 millions of ergs/gram for $\theta=308°$ A.
79569	67248	$P_xP_xP_{sx}P_{sx}\theta_x$	$\theta_xP_yP_yP_{sy}P_{sy}$	Actual pressure for $\theta=296°$ A., 790 mb. Condensation pressure for $\theta=296°$A., 560 mb. Lowest potential-temperature surface $\theta=296°$A. Actual pressure for $\theta=302°$A., 720 mb. Condensation pressure for $\theta=302°$A., 480 mb.
6240		$P_zP_zP_{sz}P_{sz}$		Actual pressure for $\theta=308°$A., 620 mb. Condensation pressure for $\theta=308°$A., 400 mb.
224830	423520	$D_1D_1S_1S_1D_2D_2$	$S_2S_2D_3D_3S_3S_3$	Direction of shear-stability ratio vector for $\theta=296°$A., 220°. Magnitude of shear-stability ratio vector for $\theta=296°$A., 48 decameters/second. Direction of shear-stability ratio vector for $\theta=302°$A., 300°. Magnitude of shear-stability ratio vector for $\theta=302°$A., 42 decameters/second. Direction of shear-stability ratio vector for $\theta=308°$A., 350°. Magnitude of shear-stability ratio vector for $\theta=308°$A., 20 decameters/second.

[1] Actually 220. [2] Unknown. Readings of hair hygrometer unreliable at low temperatures.

(*b*) Message received by teletype: E004 12841 04842 21930 48555 36595 69033 41115 99129 48586 37318 52376 66213 4298 75// 79611 0614 08060 05// 16661 68879 98861 9341// 80779 66563 //// ///// /////.

Coded				Decoded					
Code figures		Code symbols							
E004		$11G_1G_1$		El Paso, Tex.; hour of apob take-off, 4 a. m., 75th-meridian time					
				Data for levels					
				Level number	Elevations, m. (m. s. l.)	Barometric pressure (mb.)	Temperature (° C.)	Relative humidity (percent)	Mixing ratio (g./kg.)
12841	04842	HHPPT	TUUmm	Surface	[1] 1, 200	884	10	48	4. 2
21930	48555	HHPPT	TUUmm	1	2, 100	793	4	85	5. 5
36595	69033	HHPPT	TUUmm	2	3, 600	659	−6	90	3. 3
41115	99129	HHPPT	TUUmm	3	4, 100	611	−9	91	2. 9
48586	37318	HHPPT	TUUmm	4	4, 800	558	−13	73	1. 8
52376	66213	HHPPT	TUUmm	5	5, 200	537	−16	62	1. 3
4298	75//	$P_aP_aP_bP_b$	$P_cP_cP_dP_d$	Barometric pressure ... {842 mb. at 1,520 m. 698 mb. at 3,050 m. 575 mb. at 4,570 m. No data for 6,100 m.					
79611	0614	$P_1P_1P_2P_2hp$	N_eCdd	Base observed at 790 mb. pressure. Top observed at 610 mb. pressure. 10 Sc direction 140°.					
08060	05//	$P_1P_1P_2P_2hp$	N_eCdd	Base and top above maximum elevation of ascent. 10 As direction unknown.					
16661		$w_3P_3P_3P_4P_4$		Hard ice formed on airplane between levels at 660 and 610 mb. pressure.					
68879		$w_3P_3P_3P_4P_4$		Rain encountered between levels at 880 and 790 mb. pressure.					
98861		$w_3P_3P_3P_4P_4$		Turbulence encountered between levels at 880 and 610 mb. pressure.					
9341//		$\psi_x\psi_x\psi_y\psi_y\psi_s\psi_s$		Stream function 2,993 millions of ergs/gram for $\theta=296°$ A. Stream function 3,041 millions of ergs/gram for $\theta=302°$ A. Observation yields no stream function data for $\theta=308°$ A.					
80779	66563	$P_xP_xP_{cx}P_{cx}$	$P_yP_yP_{cy}P_{cy}$	Actual pressure for $\theta=296°$ A., 800 mb. Condensation pressure for $\theta=296°$ A., 770 mb. Lowest potential-temperature surface, $\theta=296°$ A. Actual pressure for $\theta=302°$ A., 650 mb. Condensation pressure for $\theta=302°$ A., 630 mb.					
////		$P_sP_sP_{cs}P_{cs}$		Observation yields neither actual nor condensation pressure for $\theta=308°$ A.					
//////	//////	$D_1D_1S_1S_1D_2D_2$	$S_2S_2D_3D_3S_3S_3$	Observation yields no shear-stability ratio vector data because of insufficient upper-air wind data, due to low clouds.					

[1] Actually 1,193.

(*c*) Message received by teletype: NA311 02905 28628 07265 89322 //9// 21736 99310 22586 79313 35407 69107 37247 68805 53958 97102 3378 44// 93771 0627 74665 6432 08474 79974.

Coded		Decoded					
Code figures	Code symbols						
NA311	$IIY_1G_1G_1$	Nashville, Tenn.; apob flight made Tuesday; take-off at 11 a. m., 75th-meridian time.					
		Data for levels					
		Level number	Elevations, m. (m. s. l.)	Barometric pressure (mb.)	Temperature (° C.)	Relative humidity (percent)	Mixing ratio (g./kg.)
02905 28628	HHPPT TUUmm	Surface	[1] 200	990	−2	86	2. 8
07265 89322	HHPPT TUUmm	1	700	926	−8	93	2. 2
//9//	//9//	Data between 700 and 2,100 m. are missing, and it is uncertain whether there are significant levels between those heights.					
21736 99310	HHPPT TUUmm	2	2, 100	773	−19	93	1. 0
22586 79313	HHPPT TUUmm	3	2, 200	758	−17	93	1. 3
35407 69107	HHPPT TUUmm	4	3, 500	640	−26	91	. 7
37247 68805	HHPPT TUUmm	5	3, 700	624	−26	88	. 5
53958 97102	HHPPT TUUmm	6	5, 300	495	−39	71	. 2
3378 44//	$P_aP_aP_bP_b$ $P_cP_cP_dP_d$	Barometric pressure: 833 mb. at 1,520 m.; 678 mb. at 3,050 m.; 544 mb. at 4,570 m.; No data for 6,100 m.					
93771 0627	$P_1P_1P_2P_2h_p$ N_cCdd	Base observed at 930 mb. pressure. Top observed at 770 mb. pressure. 10 Sc direction 270°.					
74665 6432	$P_1P_1P_2P_2h_p$ N_cCdd	Base estimated at 740 mb. pressure. Top estimated at 660 mb. pressure. 6 Ac direction 320°.					
08474	$w_3P_3P_3P_4P_4$	Rime formed on airplane between levels at 840 and 740 mb. pressure.					
79974	$w_3P_3P_3P_4P_4$	Snow encountered between levels at 990 and 740 mb. pressure. (Figures for stream functions and related pressures and shear-stability ratio vector data are omitted, since the potential temperatures specified occur above the maximum altitude of the flight.)					

[1] Actually 180.

NOTE.—Due to lack of data for the stratum from 700 meters to 2,100 meters, some uncertainty exists regarding the accuracy of the elevations above 700 meters and the pressures at fixed levels.

(*d*) Message received by teletype: XW07 APWE.

Coded	Decoded
XW07	Maxwell Field, Montgomery, Alabama, apob flight; message filed at 7 AM, 75th-meridian time.
APWE	Flight not made by 7 AM, 75th-meridian time, on account of unfavorable weather conditions.

(*e*) Message received by teletype: CQN CD04 10/11/16/17 26342 15880 49460 47131.

Coded	Decoded
CQN	Correction message.
CD04	Scott Field, Belleville, Ill., ascent at 4 a. m., 75th-meridian time.
10/11/16/17	Groups numbers 10, 11, 16, and 17 of the original message to be replaced by the four following groups, respectively.
26342	Group to replace group 10 of original message.
15880	Group to replace group 11 of original message.
49460	Group to replace group 16 of original message.
47131	Group to replace group 17 of original message.

62. Code for transmission of air-mass and frontal analyses (AMAFA) by teletype and radio.—*a. General.*—The central office of the Weather Bureau places the results of the air-mass and frontal analysis of the 7:30 AM, Eastern Standard Time, map on the teletype circuits at Washington, daily at 11:55 AM, Eastern Standard Time, to be relayed to all airway-communications circuits. This includes an analysis of the Northwest Pacific prepared at San Francisco, California, and transmitted to Washington for incorporation in the Washington analysis.

b. Description of code.—(1) *Heading.*—The heading of the transmission consists of the Washington designator (WA); the symbol "AMAFA," meaning "air-mass and frontal analysis"; the date and time of map analyzed, using figures. For example: "WA AMAFA 2407 . . ." would be decoded as "Washington air-mass and frontal analysis of the 7:30 AM, EST, map for the 24th of the month."

(2) *Body of AMAFA report.*—(*a*) Following the heading is one space and then a type-of-front symbol group to indicate the type of front to follow in the message. The following symbols are employed to designate the types of front:

⦶	Cold front.	⊕+	Warm front frontogenesis.
◍	Occluded front.	⦶⊕+	Stationary front frontogenesis.
⊕	Warm front.	⦶−	Cold front frontolysis.
↑⊕↑	Warm front aloft.	⊕−	Warm front frontolysis.
↑⦶↑	Cold front aloft.	⦶⊕−	Stationary front frontolysis.
↑◍↑	Occluded front aloft.	◍−	Occluded front frontolysis.
⦶⊕	Stationary front.		
⦶+	Cold front frontogenesis.		

(*b*) Following the type-of-front group is a space and then the latitude and longitude, in the order named, of the beginning point of that front, followed by the latitude and longitude of one or more

points on the front (as many as are necessary to outline properly the position of the front), the group of figures representing the latitude and longitude of any particular point being separated from any other group by a space. Thus "48105 4590" would indicate latitude 48° and longitude 105° for the beginning point, and latitude 45° and longitude 90° for the second point, etc. If a front is continuous, also if a series of fronts are located with respect to each other so as to form a continuous smooth line, the transmission for the entire series is made without a break. When the type of front changes, a symbol for the new type will be sent for the first point on it, and then will follow the coordinates of latitude and longitude. Further, if one front is attached to another at an acute angle and is plainly not a part of a continuous smooth front, or a continuous series of fronts, the latitude and longitude of the connecting point will be given in the first series of points in its proper order, and also the second series of points will either begin or end with the latitude and longitude of the connecting point. Each front, or series of fronts representing a single continuous line, is followed by two periods to separate it from data for other continuous fronts.

(*c*) Immediately following the two periods sent behind the last coordinate groups designating the locations of points on the fronts, there will be sent the air-mass groups, consisting of two, four or six two-figure symbols for the appropriate air masses, followed in each case by a four- or five-figure group for the coordinates of latitude and longitude in the same manner as points on a front are sent. These will indicate the locations on the map at which air-mass designators should be placed to complete the analysis begun by the entries of the fronts. Following the last of the coordinates, two periods will be sent.

(*d*) Each symbol for types of air masses will be composed of two figures, the first known as the mass and the second as the thermodynamic property, as follows:

Symbol	*Mass*		*Symbol*	*Thermodynamic property*
1	Continental or dry Arctic	cA.	0	Indeterminate or questionable.
2	Continental or dry Polar	cP.	1	Warm relative to the surface (w).
3	Superior	S.	2	Cold relative to the surface (K).
4	Maritime or moist Arctic	mA.		
5	Maritime or moist Polar	mP.		
6	Maritime or moist Tropical	mT.		

(*e*) Additional symbols used are as follows:

Symbol

/ Used to indicate that the air mass to the left of the / is aloft while that to the right of it is at the surface (for instance, 52/11 indicates cAw at surface, mPk aloft).

.. End or intersection of front, or end of message.

+ Between two air-mass numbers, indicates a mixture of the two air masses.

→ "Becoming" (for instance 52→62 indicates mPk becoming mTk).

63. Weather code, numerical system for land stations.—*a. General.*—The U. S. Weather Bureau code is constructed on principles adopted by the International Meteorological Organization.

(1) Four times daily, regular observations are taken at weather stations throughout the United States, Canada, Alaska, West Indies, and islands of the Pacific, at 1830 GMT, 0030 GMT, 0630 GMT, and 1230 GMT.

(*a*) GMT refers to Greenwich meridian time, with the day beginning at midnight and the time reckoned from 0000 to 2400. Equivalent times are as follows: 1830 GMT is equivalent to 1330 EST, 1230 CST, 1130 MST, 1030 PST; 0030 GMT is equivalent to 1930 EST, 1830 CST, 1730 MST, 1630 PST; 0630 GMT is equivalent to 0130 EST, 0030 CST, 2330 MST, 2230 PST; 1230 GMT is equivalent to 0730 EST, 0630 CST, 0530 MST, 0430 PST.

(*b*) These are the times at which observations are completed, coded, and in readiness for transmission by telephone, telegraph, and radio. Observations are begun approximately 20 minutes before the indicated hours. The regular observations at certain outlying stations in Alaska, in northern Canada, in the islands of the Pacific, in the West Indies, etc., are taken earlier than the regular scheduled time in order that all reports may be collected and used synchronously.

(2) The code is composed of groups of five figures, generally, but the last group in some reports may have fewer figures; on infrequent occasions, words in plain language may be used under certain provisions.

(*a*) Exceptions to the general rule that all groups contain five figures each, occur only in the *last* group.

(*b*) Each figure of each group has a data significance which is identified by the position of the group in the message and by the position of the figure in that group.

(*c*) The number of numerical groups in a message is never less than five nor more than nine.

(*d*) Under all conditions, the order of the symbols in a group and the order of the groups in a message will be maintained.

(*e*) If plain language words appear, their use shall be governed only by instructions pertaining to the appropriate phenomena.

(*f*) Occasionally, for reasons beyond control, an observer cannot supply the data provided for in the code and code tables, in which case the usual position of the data in the code group will be indicated by a slant line (/) and not a numeral. A slant line (/) will not be used in cases where meteorological conditions prevent accurate information being secured, as in the case of an obscured sky, or where the code tables provide a proper figure to indicate the actual meteorological condition.

(*g*) The character *X* will *not* be used to indicate missing data or for any other purpose in the figure code. A mixture of figures and letters in a group is prohibited.

(*h*) Numeral groups are designated "universal" or "supplemental." A universal group is *always* included in a coded report. Supplemental groups may or may not be included, according to instructions to particular stations or according to existing meteorological conditions. Should it happen that all of the data for a universal group are missing, that group will be represented in the message by five slants, /////. Should it happen that all of the data for a supplemental group are missing, that group will be omitted. No identification, other than by position in the message, is required for universal groups, but identification of each supplemental group is either determined by a fixed identification number, or by other rules.

b. Symbol and group arrangement.—(1) Symbol and group arrangements are as follows:

(*a*) 1830 GMT observation:

(1)	(2)	(3)	(4)	(5)	(6)
IIINV	DDFww	PPPTT	$T_sT_s$app	$C_LC_MC_HhD_C$	$6R_cR_tRR$
		(7)	(8)	(9)	
		$7P_mP_mP_ma_1$	$8D_xD_xF_xF_x$	T_nT_n.	

(*b*) 0030 GMT observation:

(1)	(2)	(3)	(4)	(5)	(6)
IIINV	DDFww	PPPTT	$T_sT_s$app	$C_LC_MC_HhD_C$	$6R_cR_tRR$
		(7)	(8)	(9)	
		$7P_mP_mP_ma_1$	$8D_xD_xF_xF_x$	$T_nT_nR_sT_xT_x$.	

(*c*) 0630 GMT observation:

(1)	(2)	(3)	(4)	(5)	(6)
IIINV	DDFww	PPPTT	$T_sT_s$app	$C_LC_MC_HhD_C$	$6R_cR_tRR$
		(7)	(8)	(9)	
		$7P_mP_mP_ma_1$	$8D_xD_xF_xF_x$	T_xT_x.	

(*d*) 1230 GMT observation:

(1)	(2)	(3)	(4)	(5)	(6)
IIINV	DDFww	PPPTT	$T_sT_s$app	$C_LC_MC_HhD_C$	$6R_cR_tRR$
	(7)	(8)	(9)		
	$7P_mP_mP_ma_1$	$8D_xD_xF_xF_x$	$T_nT_nR_sT_xT_x$.		

(2) A figure for symbol R_s in group 9 of the 0030 and 1230 GMT observations is included only when there is snow on the ground.

c. Identification of code groups.—(1) The universal groups are invariably:

(*a*) The first four groups, IINV DDFww PPPTT $T_sT_s$app.

(*b*) Group (9), either T_nT_n, or $T_nT_nR_sT_xT_x$, or T_xT_x, depending upon the hour of the observation. This group will always be the last group. When there is no snow on the ground, symbol R_s will be omitted from group $T_nT_nR_sT_xT_x$.

(2) The supplemental groups:

(*a*) $C_LC_MC_HhD_C$ is the cloud group, and has no identification figure. When it appears, it is the fifth group. Presence or absence of this group in the report is indicated by the fourth figure *N* of the first group (IIINV). If the figure for sumbol N is 0 or 9, the cloud group is *not* included in the report.

(*b*) $6R_cR_tRR$ is the precipitation-thunderstorm group and is identified by the group designator *6* as the first figure. This group is included in the report only if the precipitation has occurred within a specified time preceding the observation.

(*c*) $7P_mP_mP_ma_1$ is identified by the first figure of the group, a *7*. This group is included only in reports from stations having an elevation of 3,000 feet or more above sea level.

(*d*) $8D_xD_xF_xF_x$ is identified by the first figure of the group, an *8*. This group is included in reports only when the highest 1-minute velocity of the wind during the 6 hours preceding the observation exceeds 38 miles per hour, or equals or exceeds the specified verifying velocity of the station.

d. Definition of letter symbols.

Symbol	*Data*
a	Characteristic of barometric tendency during the 3-hour period ending at time of observation. (Code table 27.)
a_1	Characteristic of barometric tendency during the 3-hour period ending 3 hours preceding the time of observation. (Code table 27.)
C_L	Form of low cloud. (Code table 17. See Circular S.)
C_M	Form of middle cloud. (Code table 18. See Circular S.)
C_H	Form of high cloud. (Code table 19. See Circular S.)

Symbol	*Data*
D_C	Direction from which cloud is moving, coded to eight points of the compass. (Code table 21.)
DD	Direction from which wind is blowing, coded to 16 points of the compass. (Code table 22.)
D_xD_x	Direction of highest wind during the 6 hours preceding the time of observation; coded to 16 points of the compass. (Code table 22.)
F	Force of wind according to the Beaufort scale, at the time of observation. (Code table 23a.)
F_xF_x	Highest 1-minute wind velocity observed during the 6 hours. The group in which this appears is sent only when any 1-minute velocity exceeds 38 miles per hour or exceeds the specified verifying velocity of a station. The code is in miles per hour.
h	Lowest height above the ground at which the total cloudiness present covers more than five-tenths of the sky, otherwise known as the ceiling. (Code table 20.) Ceiling values are reported up to and including 9,750 feet. For the code, a ceiling over 9,750 feet is called unlimited, and is indicated by figure 9.
III	Index number which identifies the station.
N	Total amount of sky covered by clouds. (Code table 14.)
pp	Net amount of barometric-pressure change during the 3 hours preceding the time of observation; expressed in fifths of millibars. (Code table 29.)
PPP	Atmospheric pressure reduced to sea level in tenths of millibars, the hundreds digit being omitted. (Code table 30.)
$P_mP_mP_m$	Atmospheric pressure reduced to the 5,000-foot level in tenths of millibars, the hundreds digit being omitted. (Code table 31.)
R_c	Character of precipitation or thunderstorm. (Code table 24.)
R_t	Time at which the thunderstorm began, or time the precipitation began or ended. (Code table 25.)
RR	Amount of precipitation in hundredths of an inch during the 6, 12, 18, or 24 hours preceding the 1830 GMT, 0030 GMT, 0630 GMT, and 1230 GMT observations, respectively.
R_s	Depth of snow on ground at time of observation. (Code table 26.)
TT	Temperature of the air at time of observation, in whole degrees Fahrenheit.
T_nT_n	Minimum temperature of the air in whole degrees Fahrenheit during the 12, 18, or 24 hours preceding the 1230 GMT, 1830 GMT, and 0030 GMT observations, respectively.
T_dT_d	Temperature of the dew point at time of observation, in whole degrees Fahrenheit.
T_xT_x	Maximum temperature of the air in whole degrees Fahrenheit during the 12, 18, and 24 hours preceding the 0030 GMT, 0630 GMT, and 1230 GMT observations, respectively.

Symbol	*Data*
V	Horizontal visibility, or the greatest distance toward the horizon at which an object can be recognized by the unaided eye for what it is, or at which lights of known intensity can be seen at night. (Code table 15.)
ww	Weather at time of observation. (Code table 34.)

e. Description of code elements.—(1) *Station identification: symbol III.*—III is determined by a list of index numbers assigned to each station. The first three figures in the first group of each report give the index number which identifies the name and location of the station where the observation was taken. Index numbers are assigned to various stations in a systematic manner so that the number itself indicates the approximate geographic position of the station.

(*a*) In the United States and Canada, the numbers 200 to 299 are used for stations below latitude 34°, 300 to 399 between latitudes 34° and 37°, 400 to 499 between latitudes 37° and 40°, 500 to 599 between latitudes 40° and 43°, 600 to 699 between latitudes 43° and 46°, 700 to 799 between latitudes 46° and 49°, 800 to 809 for Newfoundland stations, 810 to 899 between latitudes 49° and 55°, 900 to 989 for stations above 55°, 990 to 999 for island stations in the Pacific. The numbers 000 to 099 are assigned to stations in the Caribbean Sea area and in Central America. The numbers 100 to 199 are assigned to stations in Mexico.

(*b*) Within each range of 100 numbers from 200 to 300, 300 to 400, etc., 10 divisions are made by lines running approximately north and south. A series of roughly rectangular areas, each containing 10 index numbers, result from the intersections of the parallels of latitude just mentioned and the lines which run approximately north and south. These areas are termed "decade areas." Where there are more than 10 stations within a decade area, in some cases a slant line has been substituted for the second number and the decade or second number of the group placed in the third digit. For example, if 620 to 629 were assigned to stations and another station were placed in that decade, the index number might be 6/2.

(*c*) The first digit of the three-digit index number increases going from south to north. The second digit of the index number increases going from east to west. The third digit of the index number, within a separate decade area, increases going from south to north, generally. In a few instances a station near a decade division line has been given an index number of an adjoining decade area.

(*d*) Whenever a station is discontinued, as far as practicable its

index number will not be used as an index number for another station until at least 6 months have elapsed.

(*e*) Coast Guard stations using the land code have index numbers with a slant line as the last digit of the element III.

(2) *Sky coverage: symbol N.*—(*a*) Sky coverage is based on the total visible amount of cloudiness, as projected against the dome of the sky, compared with the amount of open sky at the time of observation. The amount of coverage is determined by estimation and is reported in tenths of coverage according to code table 14.

(*b*) If no clouds are visible on account of atmospheric conditions such as fog, heavy snow, smoke, dust, etc., the sky will be reported as obscured by use of code figure 9.

(*c*) Figure 0 is used for symbol N when there are no clouds and the sky is not obscured in any way. When the sky is only partially obscured, the code figure that best represents the amount of sky covered with clouds is used.

(*d*) The amount of clouds covering the sky, represented by N, should not be at variance with the "ww" in group DDFww, and should be consistent with the cloud values represented by C_L, C_M, and C_H, in group $C_LC_MC_Hh$ D_C.

(*e*) When darkness prevents an accurate observation of cloud data, and the type and direction of cloud and height of ceiling are not known, a slant will be used for N, and the cloud group will not be included in the message. When darkness prevents an accurate observation of some cloud data, but either the type of cloud or height of ceiling or direction of cloud is known, a code figure (other than 0 or 9) will be used for N, and the cloud group will be included in the message.

(3) *Visibility: symbol V.*—Visibility is the mean greatest distance toward the horizon that prominent objects, such as mountains, buildings, towers, etc., can be seen and identified by the normal eye unaided by special optical devices. This distance must prevail over a range of more than half the horizon. At night it may be determined by observing lights whose intensity and distance from the point of observation are known.

(*a*) For determination of visibility during daylight hours, black or dark-colored objects against the sky are used. Light-colored objects and objects appearing against terrestrial backgrounds are not used. In estimating visibility from appearances of objects at a short distance, the observer notes the sharpness with which the checking points stand out.

(*b*) For determination of visibility during night hours, the light

from airway beacons is not favored because of its great penetrating power. The red or green course lights of such beacons may be used. The best check is the intensity of moderate lights at known distances and intensities, and the brilliancy of stars near the horizon. For candle power of lights stationed at the same distances as objects used in the daytime, see the right-hand column of code table 15.

(*c*) The appropriate code figure for V is determined by use of code table 15.

(4) *Direction of wind: symbols DD, D_xD_x.*—True (not magnetic) directions and true (corrected) velocities are coded.

(*a*) Wind direction refers to the direction *from* which the wind is coming, and is always coded to 16 points of the compass, each point having an even number beginning with north-northeast as "2" and ending with north as "32." (Code table 22.) When air has no perceptible motion (calm), code 00 for direction (symbol DD), and 0 for the force (symbol F.)

(*b*) Where weather stations are equipped with recording registers but not with wind-indicating devices of flashing-light or wintac-selsyn type, the wind direction will be obtained from the recording register. In this case, intermediate directions can readily be determined by the frequency of the dotted record; e. g., if the north pen arm strikes at every recording while the west arm strikes only intermittently, the wind is from the north-northwest.

(*c*) When the station is not equipped with wind instruments, the direction may be determined by observing the drift of smoke, or the direction in which twigs, leaves, etc., are swaying. If the station is located at an airport, the direction can be obtained from the wind cone or tee.

(*d*) DD is the wind direction at the time of observation. D_xD_x is the direction of the highest wind velocity within the 6 hours preceding the time of observation.

(5) *Force of wind: symbol F.*—(*a*) True, corrected velocities are recorded and coded. If no wind-indicating or recording instrument is available, the velocity may be estimated by application of values given by the table of Beaufort scale. See code table 23b.

(*b*) If the cups of the anemometer are not moving, or if smoke rises vertically, the velocity will be zero and the code figure for F will be 0.

(*c*) When the wind force at the time of the observation exceeds force 9, the figure 9 is coded for symbol F, and a word is added in plain language at the end of the message as follows: GALE (for force 10); STORM (for force 11); or HURRICANE (for force 12).

(*d*) The code figure for F is determined by use of code table 23a.

(6) *Force of wind; data for highest wind velocity: symbol* F_xF_x.—The highest wind reported is the highest 1-minute occurrence observed during the 6 hours preceding the time of observation.

(*a*) Stations having automatic wind recorders will code the highest velocity recorded during a 1-minute period (estimated as closely as possible).

(*b*) If a station is equipped with a one-sixtieth-mile indicating anemometer, the highest 1-minute velocity which occurs at any regular or special observation will be coded.

(*c*) Stations assigned "verifying velocities" will report the highest wind speed whenever their specified verifying velocity has been reached or exceeded. Stations not assigned "verifying wind velocities" will report highest wind speeds whenever a velocity of 39 miles per hour has been reached or exceeded.

(*d*) Highest wind speeds are coded in the actual miles per hour observed, unless the highest wind velocity exceeds 99 miles per hour. In this case, the code figures 99 are used for symbol F_xF_x and words in plain language are added at the end of the message to indicate the actual highest velocity which occurred. Examples: "HUNDRED FIFTEEN," "HUNDRED TWENTY FOUR," etc.

(7) *Present weather: symbol* ww.—The symbol ww (code table 34) represents the weather at the time of the observation, except under certain conditions which are indicated in the code table. For correct coding of present weather, the observer should know the character of the weather which occurred during the hour prior to the time of observation.

(*a*) Should more than one of the descriptions in the ww table be applicable to the weather at the time of the observation, the description with the highest code number is used.

(*b*) The weather represented by "ww" should not be at variance with other data of the report. The ww code used should have the same visibility limits as that given in the code for V in the first group, IIINV. When ww is 00, symbol N is coded 0 or 1; when ww is 01, symbol N is coded as 2, 3, or 4; when ww is 02, symbol N is coded as 4, 5, or 6; when ww is 03, symbol N is coded as 7 or 8. When symbol N is coded as 4 and present weather is coded as 01, the total amount of sky covered is five-tenths or less, and there are scattered clouds. (The ceiling is unlimited and coded as 9 for h.) When symbol N is coded as 4 and the present weather is coded as 02, the total amount of sky covered is more than five-tenths and the sky is

broken. (There would be a ceiling value for "h" if the height of the lowest clouds covering more than five-tenths of the sky were less than 9,751 feet.)

(*c*) Code figures 00 to 19 inclusive are used only when no precipitation has occurred at the station during the hour preceding the time of the observation.

(*d*) Code figures 20 to 29, inclusive, for ww are used only when precipitation has occurred during the hour preceding the time of observation and *is not occurring* at the time of observation.

(*e*) The code figures 20, 30, 40, 50, 60, 70, 80, and 90 (those which begin their particular decade groups) are general descriptions, and are used only when the observer is unable to determine which higher number in the appropriate decade group correctly describes the phenomena.

(*f*) When precipitation is not occurring at the time of observation, the appropriate code figure is selected from the figures 00 to 49 inclusive. When precipitation is occurring at the time of observation, the appropriate code figure is selected from the code figures 50 to 99 inclusive.

(*g*) Observations of these phenomena are made visually without the aid of instruments, except where wind velocities are involved as a measure of intensity of the phenomena in question, in which cases an anemometer is used.

(8) *Symbols for pressure elements of the code.*—(*a*) PPP is the atmospheric pressure corrected for instrumental errors, temperature, and gravity. It is then reduced to sea level. It is coded in tenths of millibars with the initial figure 9 or 10, which represents the hundreds of millibars, omitted. Code table 30 gives the pressure in inches (at sea level) reduced to millibars. Example: 1,025.7 millibars would be coded as 257; 984.1 millibars would be coded as 841. Station pressures will be based on the mercurial-barometer readings. To reduce the pressure to sea level, it is not permissible to apply a given, fixed reduction factor, i. e., an amount which must be added to the "station pressure" to obtain the sea-level expression, unless the station pressures and the actual temperature arguments, for the successive times when referred to the reduction table, happen to give the same value. Unless special instructions are given to the contrary, the temperature argument used in the reduction of barometric pressure to sea level should be obtained by adding to the current dry-bulb reading the dry-bulb reading 12 hours ago, and dividing the sum by two. This average (the

above quotient) should be used as the basis for computing the sea-level pressure from the reduction tables.

(*b*) $P_mP_mP_m$ is the pressure of those stations having an elevation greater than 3,000 feet above sea level, reduced to 5,000 feet above sea level. (See code table 31.) This datum is reported in tenths of millibars, with the initial figure 9 or 10, which represents the hundreds of millibars, omitted.

(*c*) "a" is the characteristic of barometric tendency or change of the last 3 hours. "a_1" is the pressure characteristic of the 3-hour period ending 3 hours ago. (See code table 27.) The characteristic of the barometric tendency is determined from examination of the barograph trace, without making allowance for the diurnal change. If the station is without a barograph, or the barograph is out of order, the barometric tendency may be obtained from hourly readings of the mercurial barometer. Where this is impossible, slant lines (/) will be used for symbols a, a_1 and pp.

(*d*) "pp" is the net change of pressure during the period of 3 hours preceding the time of observation. This change is determined from the barograph reading. It is reduced to *fifths* of millibars, and so coded, by use of code table 29. When the amount is 20 millibars or more, the word TWENTY is placed at the end of the message, the actual amount is reduced by 20 millibars, and the remainder, in fifths, is coded for symbol pp. Examples: A 3-hour net change is 3.4 mb. or .10 inch of mercury. "pp" is coded as 17 (for 17 fifths of millibars.) A 3-hour net change is 20.0 millibars or 0.59 inch of mercury. "pp" is encoded as 00, and the word TWENTY is placed at the end of the message.)

(9) *Temperature: symbols* TT, T_sT_s, T_nT_n, and T_xT_x.—(*a*) TT is the free air temperature at the time of observation.

(*b*) T_sT_s is the temperature of the dew point (reported only by those stations equipped with a psychrometer).

(*c*) T_nT_n and T_xT_x will be discussed later.

(*d*) All temperatures (that at the time of observation, the dew point, the minimum, and the maximum) are coded to the nearest whole degree Fahrenheit. The actual temperature is the code figure sent excepting:

1. For temperatures below zero degree Fahrenheit, the number 100 is added algebraically and the numerical sum is used. Examples: −15° is coded as 85; −1° is coded as 99.

2. For temperatures of 100° or higher, the number 100 is sub-

tracted from the actual temperature reading and the numerical result is used. Example: 107° is coded as 07; 100° is coded as 00.

(10) *Temperatures, minimum and maximum, reported in the ninth group:* $T_nT_nR_sT_xT_x$.—These temperatures are reported as follows:

(*a*) T_nT_n, minimum temperature, in the 1230 GMT report is the minimum during the 12 hours preceding the observation; in the 1830 GMT report it is the minimum during the 18 hours preceding the observation; in the 0030 GMT report it is the minimum during the 24 hours preceding the observation.

(*b*) T_xT_x, maximum temperature, in the 1230 GMT report is the maximum during the 24 hours preceding the observation; in the 0630 GMT report it is the maximum during the 18 hours preceding the observation; in the 0030 GMT report it is the maximum during the 12 hours preceding the observation.

(*c*) Inasmuch as R_s, the snow on the ground, is reported only when there is snow on the ground, there may be times when group $T_nT_nR_sT_xT_x$ will have only two or four figures, depending on the time of the observation.

(11) *Supplemental group for clouds:* $C_LC_MC_HhD_C$.—(*a*) It may sometimes happen that the first figure in the cloud group may correspond with the identification figure of another supplemental group (6, 7, or 8) since the cloud group does not have any special supplement designator. Confusion should rarely occur, for when the cloud group is included in a report it is always the fifth group.

(*b*) No cloud group will be sent if an N code figure of 0 or 9 is sent (N is the sky coverage in the first group, IIINV), if there are no clouds in the sky at the time of observation, or when a slant (/) is used for symbol N.

(*c*) For low clouds, C_L, the code figure used will be in agreement with the classification of low clouds according to Circular S, "Codes for Cloud Forms and States of Sky," "The International Atlas of Clouds and States of Sky," and code table 17. Low clouds are of two general types: Those whose mean lower level is close to the surface of the earth and whose mean upper level is 6,500 feet; clouds of vertical development whose mean lower level is 1,600 feet and whose mean upper level is that of C_H, the high clouds. When there are no lower clouds, but there are either middle or high clouds, or both middle and high clouds, C_L will be coded as 0.

(*d*) For middle clouds, C_M, the code figure used will be in agreement with the classification of middle clouds according to Circular S, "Codes

for Cloud Forms and States of Sky," "The International Atlas and States of Sky," and code table 18. Middle clouds have a mean lower level of 6,500 feet and a mean upper level of 20,000 feet. When there are no middle clouds visible (there may be some above a continuous layer of low clouds), and there are either low or high, or both low and high clouds, 0 is coded for C_M.

(*e*) For high clouds, C_H, the code figure used will be in agreement with the two classification books named above and with code table 19. High clouds have a mean lower level of 20,000 feet. When there are no high clouds visible, but there are other clouds, 0 will be coded for C_H. (There may be high clouds which are hidden by a continuous layer of low or middle clouds, but the high clouds are coded as 0.)

(*f*) Ceiling, h, is the height in feet of the lowest level at which total cloudiness (as projected against the entire dome of the sky) between earth's surface at the station and that level covers more than one-half the entire area of the sky; except that in the presence of heavy precipitation, dense fog, or other conditions which prevent the observer from seeing any cloudiness that may be present, the ceiling will be zero, that is, at the surface. If the ceiling is 10,000 feet or more, it is considered "unlimited" for the purpose of coding and decoding regular coded weather reports. Ceiling values will be reported to the nearest 100 feet up to 5,000. Above 5,000 feet, the height will be reported to the nearest 500 feet up to 9,751 feet, above the station when the total cloudiness below 9, 751 feet above the station covers over five-tenths of the sky. Ceiling values will be coded according to code table 20.

(*g*) For cloud direction, D_C, when the direction cannot be determined at the time of observation but has been determined within 1 hour preceding, the figure for the previously determined direction is used. When motion is so slow that a true direction cannot be determined, or when cloud direction is variable, code figure 0 is used. When the direction is unknown, code figure 9 is used. Direction, or D_C, refers to the direction of C_M, middle cloud, whenever middle cloud is observed; of C_H, high cloud, whenever middle cloud is not observed and high cloud is observed; or of C_L, low cloud, whenever low cloud is the only form observed. Cloud direction refers to the direction *from* which the cloud is moving, and is coded according to code table 21.

(12) *Supplemental "6" group for precipitation and thunderstorms:* $6R_cR_tRR$.—(*a*) This group is sent only when precipitation has

occurred within the precipitation measuring periods, or when thunderstorm has occurred. Stations not equipped with rain gages will not attempt to report amounts of precipitation (RR), but will use the appropriate code figures for R_c and R_t and use two slants (//) for RR. Precipitation is measured in hundredths of inches of water equivalent.

(*b*) Precipitation measuring periods for reporting precipitation in numerical code are as follows: In the 1230 GMT report, the total amount in the previous 24 hours is reported and coded for RR; in the 0630 GMT report, the total amount in the previous 18 hours; in the 0030 GMT report, the total amount in the previous 12 hours; and in the 1830 GMT report, the total amount in the previous 6 hours. Current readings at Army Air Corps stations for precipitation are made at 0800 LST only.

(*c*) The character of the precipitation or thunderstorm which has occurred in the specified period preceding the time of observation is coded for R_c according to code table 24. When only a "trace" of precipitation occurs before or after a thunderstorm with no precipitation (dry thunderstorm) at the station, the code figure 9 is always used in preference to code figure 8 for R_c. However, if the "trace" which occurred *before* a thunderstorm with no precipitation at the station has been reported in the previous regular report, the code figure 8 will be used for R_c. A "trace" of precipitation, or a thunderstorm with no precipitation at the station, or a thunderstorm with a trace of precipitation at the station, that is reported in a regular scheduled report (*and RR is 00*), is not coded again in any following regular reports, unless it occurs at the time of observation. Whenever R_c is not coded as 8, the presence of the precipitation group in the report indicates precipitation has occurred at the station. Whenever R_c is coded as 8, and RR is 00, the presence of the group indicates no precipitation has fallen since the last previous regular observation. When two or more separate thunderstorms, or two or more separate precipitation periods, or a thunderstorm and a separate rain period occur in the measurement period preceding the time of observation, the character (R_c) of the *last* occurrence is coded as R_c, except that when a thunderstorm has occurred and has not been reported in a previous regular scheduled report, the code figures 8 or 9 are always used for R_c in preference to lower figures. An appropriate code figure must be used for both R_c and R_t whenever the precipitation-thunderstorm group is included in the report.

(*d*) The time of the precipitation or thunderstorm, R_t (code table 25), is determined as follows: For a thunderstorm, the time refers to

when the thunderstorm began; for precipitation, the time refers to when the precipitation began or ended. When R_c is coded as 8 or 9, R_t is the time the thunderstorm began. The time of precipitation, if any, is not sent. The first thunder heard at the station will be taken as the time of the thunderstorm. If R_c is coded as 0 through 7, R_t is the time precipitation began, if precipitation is falling at the time of observation. R_t is the time the precipitation ended, if precipitation is not falling at the time of observation. An inspection of the code figure for "ww" is necessary to determine whether or not precipitation is in progress at the time of observation. If precipitation is in progress, R_t is the time that the phenomenon began.

(*e*) The amount of precipitation, RR, is measured in hundredths of inches of water-equivalent during the specified period preceding the time of observation. When the total amount of precipitation is a trace, or less than .01 inch, the symbol RR is coded 00. Actual hundredths of inches up to 0.99 inch are coded as whole numbers for RR. When a thunderstorm with no precipitation at the station occurs, the symbol RR is coded as 00, provided less than 0.01 inch has fallen at any time in the measurement period preceding the observation. There should be no confusion regarding this requirement because R_c coded as 8 means "thunderstorm with no precipitation at the station." When the amount of precipitation is 1 inch or more, a plain language word, the whole inches of precipitation (ONE, TWO, FOUR, etc.), is placed in the message, immediately preceding the precipitation group. The remaining hundredths of an inch are coded for RR.

(*f*) Examples of coding precipitation and thunderstorm:

1. A single occurrence since the 1230 GMT observation.

Code	*Data*
64742	Showers ended 6 to 12 hours ago; total 0.42 inch.
ONE 66534	Continuous rain ended 4 to 5 hours ago; total is 1.34 inches.
68300	Thunderstorm with no precipitation at the station began 2 to 3 hours ago. Precipitation is "zero."
69835	Thunderstorm with precipitation at station began 12 to 18 hours ago; total precipitation is 0.35 inch.
65200	Drizzle ended 1 to 2 hours ago; total precipitation is "trace."

2. Multiple occurrences since 1230 GMT observation.

69319	Thunderstorm, with 0.19 precipitation at the station, began 2 to 3 hours ago. (In this case

a thunderstorm without precipitation which occurred 5 to 6 hours ago was not coded.) Total precipitation is 0.19.

68244---------- A thunderstorm with no precipitation at the station began 1 to 2 hours ago. (In this case there was not coded a thunderstorm with 0.44-inch precipitation which occurred 5 to 6 hours ago.) Total precipitation 0.44 inch.

63412---------- Intermittent rain with 0.09-inch precipitation ended 3 to 4 hours ago. (In this case there was not coded a thunderstorm with 0.03-inch precipitation at the station which occurred more than 6 hours ago and which was coded in a previous report.) Total precipitation 0.12 inch.

69600---------- A thunderstorm with no precipitation occurred 5 to 6 hours ago. In this case a trace of precipitation which occurred 2 to 3 hours ago is accounted for by using code figure 9 in preference to 8 for R_c. Total is "trace."

64756---------- Showers of 0.30-inch precipitation ended 6 to 12 hours ago. (In this case a thunderstorm which occurred 12 to 18 hours ago with 0.26-inch precipitation at the station was not coded.) Total amount is 0.56 inch.

(13) *Supplemental "7" group for pressure data at 5,000 feet above sea level:* $7P_mP_mP_ma_1$.—(*a*) This group is included only in reports from stations having an elevation of 3,000 feet or more above sea level. The supplemental designator is a "7." The group follows immediately the fourth universal group, if there are no precipitation or clouds reported. It follows the cloud group if there is no precipitation report made. If there is a report of precipitation included, the supplemental 7 group follows it directly.

(*b*) $P_mP_mP_m$ is the barometric pressure in units and tenths of millibars corrected for instrumental error, temperature, and gravity, and then reduced to the 5,000-foot level above sea level. $P_mP_mP_m$ is similar to PPP and instructions are similar, except that $P_mP_mP_m$ is reduced to the 5,000-foot level and PPP is reduced to sea level. See (8) above, also code table 31.

(*c*) a_1 is the pressure characteristic for the 3-hour period ending 3 hours previous to the observation. It is determined in the same manner as "a," except that for a_1 the characteristic is for the 3 hours preceding the data for "a." See (8)(*c*) above.

(14) *Supplemental "8" group for excessive wind speeds:* $8D_xD_xF_xF_x$.—(*a*) "8" is the supplemental designator. This group follows the first

four universal groups and any intervening supplemental groups that have been included in the report. The only group that follows it contains the data for maximum and minimum temperatures, and for the snow depth if that is sent. The number of figures appearing in the last group depends on the time of the observation and the presence of snow on the ground.

(*b*) See (4) above, for D_xD_x, and (6) for F_xF_x.

(*c*) When the highest wind velocity occurs at the time of the observation, the highest wind group $8D_xD_xF_xF_x$ is included in the mesage. In such cases, the coded figures for DD and D_xD_x are the same, and the coded figures for F and F_xF_x represent the same wind speeds or force.

(15) *Universal group* T_nT_n, T_xT_x, $T_nT_nT_xT_x$, *or* $T_nT_nR_sT_xT_x$.—(*a*) T_nT_n is the minimum temperature, and T_xT_x is the maximum temperature, which occurred within a certain number of hours of the observation, depending on the time of observation. See (9) and (10) above, for a discussion of maximum and minimum temperatures.

(*b*) R_s is depth of snow on the ground. (See code table 26.) When snow is on the ground at the time of observation, its depth is coded as R_s in group $T_nT_nR_sT_xT_x$ and is sent only with the 0030 GMT and 1230 GMT reports. Ice on the ground is also considered in coding R_s. The accumulated depth of snow and/or ice is coded regardless of when it occurred. When there is no snow on the ground at the time of the observation, the figure for symbol R_s is omitted, and the group will consist of only four figures representing the minimum and maximum temperatures. Difficulties encountered at certain stations in securing accurate and uniform observations of depth of snow are recognized. Because "depth of snow on the ground" is coded primarily for synoptic purposes, observers are not charged with errors when small differences between actual and coded depths occur.

(16) *Frost.*—(*a*) Frost has no letter symbol and is indicated in plain language at the end of the message by either the word LIGHT or HEAVY, whichever is appropriate. The word "killing" is not used in coding frosts. A word for frost is included only in the 1230 GMT report.

(*b*) First-order stations and designated second-order stations report frosts which occur after vegetation has advanced sufficiently in the spring to be injured by frost, and thereafter until killing frosts have occurred in the autumn, except those stations in California, southern

rizona, Florida, and along the Gulf coast which report frosts throughout the year.

(17) *Corrections.*—Corrections of errors made in observation reports will not be telegraphed on the initiative of the observer.

f. Observations and reports by stations not on teletype circuits.—Stations which are not on the teletype circuits and which have been designated to do so will telegraph reports at 0430 EST, 1030 EST, 1630 EST, and 2230 EST using the data: IIINV DDFww PPPTT $T_sT_s$app $C_LC_MC_HhD_C$ $6R_cR_t$. The group $6R_cR_t$ will be sent only when precipitation or a thunderstorm has occurred since the observation taken 3 hours previously. No precipitation or thunderstorm within the 3 hours previous to the observation will be indicated by the absence of the last three-figure group. The last group will not include the amount of precipitation.

g. Examples of coded observations.—Twelve examples of coded reports are included herein:

(1) *Example 1, a 1230 GMT observation:*

57667 16502 19364 60005 40136 76283 5870

Code	*Symbol*	*Data*	*Code table*	*Decoded*
576	III	Name of station	(Table 43)	Lander, Wyo.
6	N	Total amount of clouds	(Table 14)	9 tenths.
7	V	Visibility	(Table 15)	6 miles.
16	DD	Wind direction	(Table 22)	South.
5	F	Wind force (Beaufort scale)	(Table 23a)	5.
02	ww	Present weather	(Table 34)	Cloudy.
193	PPP	Pressure (sea level)	(Table 30)	1019.3 mb.
64	TT	Temperature of air		64° F.
60	T_sT_s	Temperature of dew point		60° F.
0	a	Barometric tendency	(Table 27)	Rising then falling.
05	pp	Amount (net change) of tendency.	(Table 29)	+1.0 mb.
4	C_L	Form of low cloud	(Table 17)	Stratocumulus.
0	C_M	Form of middle cloud	(Table 18)	None.
1	C_H	Form of high cloud	(Table 19)	Cirrus, fine.
3	h	Height of ceiling	(Table 20)	600 to 999 feet.
6	D_C	Direction of cloud	(Table 21)	West (cirrus).
7	7	Group identifying number		
628	$P_mP_mP_m$	Pressure (5000-foot level)	(Table 31)	862.8 mb.
3	a_1	Barometric tendency ending 3 hours ago.	(Table 27)	Rising or steady; barometer 3 hours ago same as or higher than 6 hours ago.

Code	Symbol	Data	Code table	Decoded
58	T_nT_n	Minimum temperature		58° F.
70	T_xT_x	Maximum temperature		70° F.

NOTE.—This report also indicates by the omission of particular figure groups that there has been absolutely no precipitation or thunderstorm in the past six hours, that there has been less than 0.01 inch of precipitation in the past 24 hours, that the highest wind velocity in the past 6 hours was less than 39 miles per hour. By the omission of a figure for R_s in the last group the report also indicates that there was no snow on the ground at the time of observation.

(2) *Example II, a 1230 GMT observation:*

55318 28200 32940 28/// 00195 65711 3650 LIGHT

553	III	Name of station	(Table 43)	Omaha, Nebr.
1	N	Total amount of clouds	(Table 14)	Less than 1 tenth.
8	V	Visibility	(Table 15)	12 miles.
28	DD	Wind direction	(Table 22)	Northwest.
2	F	Wind force (Beaufort scale)	(Table 23a)	2.
00	ww	Present weather	(Table 34)	Clear.
329	PPP	Pressure (sea level)	(Table 30)	1032.9 mb.
40	TT	Temperature of air		40° F.
28	T_dT_d	Temperature of dew point		28° F.
/	a	Barometric tendency	(Table 27)	Barograph broken.
//	pp	Amount (net change) of tendency.	(Table 29)	Barograph broken.
0	C_L	Form of low cloud	(Table 17)	None.
0	C_M	Form of middle cloud	(Table 18)	None.
1	C_H	Form of high cloud	(Table 19)	Cirrus fine (scarce).
9	h	Height of ceiling	(Table 20)	Unlimited.
5	D_C	Direction of cloud	(Table 21)	Southwest (cirrus).
6	6	Group identifying number		
5	R_c	Character of precipitation	(Table 24)	Drizzle.
7	R_t	Time of precipitation	(Table 25)	Ended 6 to 12 hours ago.
11	RR	Amount of precipitation (hundredths).		0.11 inch.
36	T_nT_n	Minimum temperature		36° F.
50	T_xT_x	Maximum temperature		50° F.
LIGHT		Supplemental data		Light frost.

(3) *Example III, a 1230 GMT observation:*

40743 20681 09160 58520 30045 69024 81648 5870

407	III	Name of station	(Table 43)	Atlantic City, N. J.
4	N	Total amount of clouds	(Table 14)	4 to 6 tenths.
3	V	Visibility	(Table 15)	5/16 mile.
20	DD	Wind direction	(Table 22)	Southwest.
6	F	Wind force (Beaufort scale)	(Table 23a)	6.

Code	Symbol	Data	Code table	Decoded
81	ww	Present weather	(Table 34)	Showers (moderate rain).
091	PPP	Pressure (sea level)	(Table 30)	1009.1 mb.
60	TT	Temperature of air		60° F.
58	T_dT_d	Temperature of dew point		58° F.
5	a	Barometric tendency	(Table 27)	Falling, then rising.
20	pp	Amount (net change) of tendency.	(Table 29)	−4.0 mb.
3	C_L	Form of low cloud	(Table 17)	Cumulonimbus.
0	C_M	Form of middle cloud	(Table 18)	None.
0	C_H	Form of high cloud	(Table 19)	None.
4	h	Height of ceiling	(Table 20)	1,000 to 1,999.
5	D_C	Direction of cloud	(Table 21)	Southwest.
6	6	Group identifying number		
9	R_c	Character of thunderstorm	(Table 24)	Thunderstorm with rain at station.
0	R_t	Time thunderstorm began	(Table 25)	Unknown (but less than 6 hours ago).
24	RR	Amount of precipitation (hundredths).		0.24 inch.
8	8	Group identifying number		
16	D_xD_x	Direction of highest wind	(Table 22)	South.
48	F_xF_x	Force of highest wind		48 miles per hour.
58	T_nT_n	Minimum temperature		58° F.
70	T_xT_x	Maximum temperature		70° F.

(4) *Example IV, a 1230 GMT obsevation:*

53491 00046 11950 50703 ONE 66820 5060

Code	Symbol	Data	Code table	Decoded
534	III	Name of station	(Table 43)	Chicago, Ill.
9	N	Total amount of clouds	(Table 14)	Sky obscured.
1	V	Visibility	(Table 15)	150 feet.
00	DD	Wind direction	(Table 22)	Calm.
0	F	Wind force (Beaufort scale)	(Table 23a)	Zero.
46	ww	Present weather	(Table 34)	Fog, sky not discernible.
119	PPP	Pressure (sea level)	(Table 30)	1011.9 mb.
50	TT	Temperature of air		50° F.
50	T_dT_d	Temperature of dew point		50° F.
7	a	Barometric tendency	(Table 27)	Unsteady.
03	pp	Amount (net change) of tendency.	(Table 29)	−0.6 mb.
ONE	-----	Whole inches of precipitation		1 inch.
6	6	Group identifying number		
6	R_c	Character of precipitation	(Table 24)	Continuous rain.
8	R_t	Time precipitation ended	(Table 25)	12 to 18 hours ago.

Code	Symbol	Data	Code table	Decoded
20	RR	Amount of precipitation (hundredths).	----------	1.20 inch.
50	T_nT_n	Minimum temperature		50° F.
60	T_xT_x	Maximum temperature		60° F.

(5) *Example V, a 0630 GMT observation:*

68687 16103 19364 58108 72045 68408 76145 78

686	III	Name of station	(Table 43)	Salmon, Idaho.
8	N	Total amount of clouds	(Table 14)	10 tenths.
7	V	Visibility	(Table 15)	6 miles.
16	DD	Wind direction	(Table 22)	South.
1	F	Wind force (Beaufort scale)	(Table 23a)	1.
03	ww	Present weather	(Table 34)	Overcast.
193	PPP	Pressure (sea level)	(Table 30)	1019.3 mb.
64	TT	Temperature of air		64° F.
58	T_dT_d	Temperature of dew point		58° F.
1	a	Barometric tendency	(Table 27)	Rising, then steady.
08	pp	Amount (net change) of tendency.	(Table 29)	+1.6 mb.
7	C_L	Form of low cloud	(Table 17)	Stratocumulus.
2	C_M	Form of middle cloud	(Table 18)	Altostratus (thick).
0	C_H	Form of high cloud	(Table 19)	None.
4	h	Height of ceiling	(Table 20)	1,000 to 1,999 feet.
5	D_C	Direction of cloud	(Table 21)	Southwest (altostratus).
6	6	Group identifying number		
8	R_c	Character of thunderstorm	(Table 24)	Thunderstorm with no rain at station.
4	R_t	Time thunderstorm began	(Table 25)	3 to 4 hours ago.
08	RR	Amount of precipitation (hundredths).	---------	0.08 inch.
7	7	Group identifying number		
614	$P_mP_mP_m$	Pressure (5000-foot level)	(Table 31)	861.4 mb.
5	a_1	Barometer tendency ending 3 hours ago.	(Table 27)	Falling, then rising; barometer 3 hours ago lower than 6 hours ago.
78	T_xT_x	Maximum temperature		78° F.

(6) *Example VI, a 0630 GMT observation:*

62282 32479 12528 27420 50038 61724 36

622	III	Name of station	(Table 43)	Canton, N. Y.
8	N	Total amount of clouds	(Table 14)	10 tenths.
2	V	Visibility	(Table 15)	⅛ mile.
32	DD	Wind direction	(Table 22)	North.
4	F	Wind force (Beaufort scale)	(Table 23a)	4.

Code	Symbol	Data	Code table	Decoded
79	ww	Present weather	(Table 34)	Sleeting.
125	PPP	Pressure (sea level)	(Table 30)	1012.5 mb.
28	TT	Temperature of air		28° F.
27	T_dT_d	Temperature of dew point		27° F.
4	a	Barometric tendency	(Table 27)	Falling, then rising.
20	pp	Amount (net change) of tendency.	(Table 29)	+4. 0 mb.
5	C_L	Form of low cloud	(Table 17)	Stratus (or strato-cumulus in layer).
0	C_M	Form of middle cloud	(Table 18)	None.
0	C_H	Form of high cloud	(Table 19)	None.
3	h	Height of ceiling	(Table 20)	600–999 feet.
8	D_C	Direction of cloud	(Table 21)	North (stratus).
6	6	Group identifying number		
1	R_c	Character of precipitation	(Table 24)	Sleet
7	R_t	Time precipitation began	(Table 25)	6 to 12 hours ago.
24	RR	Amount of precipitation (hundredths).		0. 24 inch.
36	T_xT_x	Maximum temperature		36° F.

(7) *Example VII, an 1830 GMT observation:*

34008 30300 17382 63803 71

340	III	Name of station	(Table 43)	Little Rock, Ark.
0	N	Total amount of clouds	(Table 14)	None.
8	V	Visibility	(Table 15)	12 miles.
30	DD	Wind direction	(Table 22)	North-northwest.
3	F	Wind force (Beaufort scale)	(Table 23a)	3.
00	ww	Present weather	(Table 34)	Cloudless.
173	PPP	Pressure (sea level)	(Table 30)	1017.3 mb.
82	TT	Temperature of air		82° F.
63	T_dT_d	Temperature of dew point		63° F.
8	a	Barometric tendency	(Table 27)	Falling.
03	pp	Amount (net change) of tendency.	(Table 29)	−0.6 mb.
71	T_nT_n	Minimum temperature		71° F.

NOTE.—This example shows the least number of figure groups possible in a regular message.

(8) *Example VIII, an 1830 GMT observation:*

52886 28495 13258 57414 90037 69357 53

528	III	Name of station	(Table 43)	Buffalo, N. Y.
8	N	Total amount of clouds	(Table 14)	10 tenths.
6	V	Visibility	(Table 15)	2½ miles.
28	DD	Wind direction	(Table 22)	Northwest.
4	F	Wind force (Beaufort scale)	(Table 23a)	4.

Code	Symbol	Data	Code table	Decoded
95	ww	Present weather	(Table 34)	Moderate thunderstorm (with rain).
132	PPP	Pressure (sea level)	(Table 30)	1013.2 mb.
58	TT	Temperature of air		58° F.
57	T_dT_d	Temperature of dew point		57° F.
4	a	Barometric tendency	(Table 27)	Falling, then rising.
14	pp	Amount (net change) of tendency.	(Table 29)	+2.8 mb.
9	C_L	Form of low cloud	(Table 17)	Cumulonimbus and ragged low clouds.
0	C_M	Form of middle cloud	(Table 18)	None.
0	C_H	Form of high cloud	(Table 19)	None.
3	h	Height of ceiling	(Table 20)	600 to 999 feet.
7	D_C	Direction of cloud	(Table 21)	Northwest (Cb).
6	6	Group identifying number		
9	R_c	Character of thunderstorm	(Table 24)	Thunderstorm with rain at station.
3	R_t	Time thunderstorm began	(Table 25)	2 to 3 hours ago.
57	RR	Amount of precipitation (hundredths).		0.57 inch.
53	T_nT_n	Minimum temperature		53° F.

(9) *Example IX, an 0030 GMT observation:*

20176 26922 48973 69401 60037 FOUR 64135 82897 7177 HURRICANE TWENTY

Code	Symbol	Data	Code table	Decoded
201	III	Name of station	(Table 43)	Key West, Fla.
7	N	Total amount of clouds	(Table 14)	More than 9 tenths.
6	V	Visibility	(Table 15)	2½ miles.
26	DD	Wind direction	(Table 22)	West-northwest.
9	F	Wind force (Beaufort scale)	(Table 23a)	9 (see below).
22	ww	Present weather	(Table 34)	Rain in last hour but not at time of observation.
489	PPP	Pressure (sea level)	(Table 30)	948.9 mb.
73	TT	Temperature of air		73° F.
69	T_dT_d	Temperature of dew point		69° F.
4	a	Barometric tendency	(Table 27)	Falling, then rising.
01	pp	Amount (net change) of tendency	(Table 29)	+20.2 mb. (see below).
6	C_L	Form of low cloud	(Table 17)	Ragged low clouds.
0	C_M	Form of middle cloud	(Table 18)	None.
0	C_H	Form of high cloud	(Table 19)	None.
3	h	Height of ceiling	(Table 20)	600 to 999 feet.
7	D_C	Direction of cloud	(Table 21)	Northwest.
FOUR		While inches of precipitation		4 inches.

Code	Symbol	Data	Code table	Decoded
6	6	Group identifying number.		
4	R_c	Character of precipitation	(Table 24)	Showers.
1	R_t	Time precipitation ended	(Table 25)	Less than 1 hour ago.
35	RR	Amount of precipitation (hundreths)		4.35 inches.
8	8	Group identifying number.		
28	D_xD_x	Direction of highest wind	(Table 22)	Northwest.
97	F_xF_x	Force of highest wind		97 miles per hour.
71	T_nT_n	Minimum temperature		71° F.
77	T_xT_x	Maximum temperature		77° F.
HURRICANE		Supplemental data		Wind at time of observation is of hurricane force.
TWENTY---		Supplemental data		Amount of pressure tendency (net change) is 20.2 mb.

(10) *Example X, an 0030 GMT observation:*

61389 30903 25449 41317 86058 75274 83099 4953
HUNDRED FOURTEEN

Code	Symbol	Data	Code table	Decoded
613	III	Name of station	(Table 43)	Mt. Washington, N. H.
8	N	Total amount of clouds	(Table 14)	10 tenths.
9	V	Visibility	(Table 15)	30 miles or more.
30	DD	Wind direction	(Table 22)	North-northwest.
9	F	Wind force (Beaufort scale)	(Table 23a)	9 (47 to 54 miles).
03	ww	Present weather	(Table 34)	Overcast.
254	PPP	Pressure (sea level)	(Table 30)	1025.4 mb.
49	TT	Temperature of air		49° F.
41	T_dT_d	Temperature of dew point		41° F.
3	a	Barometric tendency	(Table 27)	Rising.
17	pp	Amount (net change) of tendency.	(Table 29)	+3.4 mb.
8	C_L	Form of low cloud	(Table 17)	Cumulus (large) and stratocumulus.
6	C_M	Form of middle cloud	(Table 18)	Altocumulus.
0	C_H	Form of high cloud	(Table 19)	None.
5	h	Height of ceiling	(Table 20)	2,000 to 2,999 feet.
8	D_C	Direction of cloud	(Table 21)	North (altocumulus).
7	7	Group identifying number		
527	$P_mP_mP_m$	Pressure (5,000-foot level)	(Table 31)	852.7 mb.
4	a_1	Barometric tendency ending 3 hours ago.	(Table 27)	Falling, then rising; barometer 3 hours ago higher than 6 hours ago.

Code	Symbol	Data	Code table	Decoded
8	8	Group identifying number		
30	D_xD_x	Direction of highest wind	(Table 22)	North-northwest.
99	F_xF_x	Force of highest wind		(See below.)
49	T_nT_n	Minimum temperature		49° F.
53	T_xT_x	Maximum temperature		53° F.
HUNDRED FOURTEEN		Supplemental data		Highest wind in preceeding 6 hours was 114 miles per hour.

(11) *Example XI, a 1230 GMT observation:*

74546 02501 15225 15712 05296 82648 19329

745	III	Name of station	(Table 43)	Duluth, Minn.
4	N	Total amount of clouds	(Table 14)	4 to 6 tenths.
6	V	Visibility	(Table 15)	2½ miles.
02	DD	Wind direction	(Table 22)	North-northeast.
5	F	Wind force (Beaufort scale)	(Table 23a)	5.
01	ww	Present weather	(Table 34)	Partly cloudy.
152	PPP	Pressure (sea level)	(Table 30)	1015.2 mb.
25	TT	Temperature of air		25° F.
15	T_dT_d	Temperature of dew point		15° F.
7	a	Barometric tendency	(Table 27)	Unsteady.
12	pp	Amount (net change) of tendency.	(Table 29)	--2.4 mb.
0	C_L	Form of low cloud	(Table 17)	None.
5	C_M	Form of middle cloud	(Table 18)	Altocumulus in bands (increasing).
2	C_H	Form of high cloud	(Table 19)	Cirrus, delicate, not increasing.
9	h	Height of ceiling	(Table 20)	10,000 (unlimited).
6	D_C	Direction of cloud	(Table 21)	West (altocumulus).
8	8	Group identifying number		
26	D_xD_x	Direction of highest wind	(Table 22)	West-northwest.
48	F_xF_x	Force of highest wind		48 miles per hour.
19	T_nT_n	Minimum temperature		19° F.
3	R_s	Depth of snow	(Table 26)	5.0 to 6.9 inches.
29	T_xT_x	Maximum temperature		29° F.

(12) *Example XII, a 1230 GMT observation:*

49407 06200 17330 27005 64500 27041 HEAVY

494	III	Name of station	(Table 43)	San Francisco, Cal.
0	N	Total amount of clouds	(Table 14)	None.
7	V	Visibility	(Table 15)	6 miles.

Code	Symbol	Data	Code table	Decoded
06	DD	Wind direction	(Table 22)	East-northeast.
2	F	Wind force (Beaufort scale)	(Table 23a)	2.
00	ww	Present weather	(Table 34)	Cloudless.
173	PPP	Pressure (sea level)	(Table 30)	1017.3 mb.
30	TT	Temperature of air		30° F.
27	T_dT_d	Temperature of dew point		27° F.
0	a	Barometric tendency	(Table 27)	Rising, then falling.
05	pp	Amount (net change) of tendency.	(Table 29)	+1.0 mb.
6	6	Group identifying number		
4	R_c	Character of precipitation	(Table 24)	Showers (of snow).
5	R_t	Time precipitation ended	(Table 25)	4 to 5 hours ago.
00	RR	Amount of precipitation		Trace.
27	T_nT_n	Minimum temperature		27° F.
0	R_s	Depth of snow	(Table 26)	Trace of snow on ground.
41	T_xT_x	Maximum temperature		41° F.
HEAVY		Supplemental data		Heavy frost.

64. Weather code, numerical system for Caribbean weather stations.—*a. General.*—The Caribbean weather code is constructed on general principles adopted by the International Meteorological Organization.

(1) It is composed of two or three groups, each group being composed of five figures. Occasionally, under special circumstances, words in plain English or Spanish are used in addition to the numerical groups.

(2) Each figure (or set of two adjacent figures) in a report represents a particular weather element, and has a value in accordance with a specified table appropriate to the particular weather element.

(3) Stations which have not been instructed to report all three five-figure groups will report only the first two groups.

(4) When absolutely no clouds are observed at the time of observation, the third group will be omitted.

(5) The number of figure groups in a message is never less than two or more than three. Under all conditions, the order of the symbols in a group and the order of the groups will be maintained.

(6) Plain language words appear infrequently and are used in connection with special or unusual phenomena. Directions for the use of these words are given in instructions pertaining to the appropriate phenomena, and under instructions to follow for additional phenomena and special observations.

(7) Occasionally, for reasons beyond control, an observer cannot supply the data provided for in the code and code tables (as in the

case of a broken, missing, or unserviceable instrument). In such cases the usual position of the data will be indicated by a character known in communication practices as a slant (/) and not by a numeral.

(8) A slant (/) will not be used in cases where meteorological conditions prevent accurate information being secured, as in the case of an obscured sky, or where the code tables provide a proper figure to indicate the actual meteorological condition.

(9) Numeral groups are usually designated Universal or Supplemental.

(*a*) A Universal group is always included in a coded report. In the Caribbean code, the first two groups are designated the Universal.

(*b*) A Supplemental group may or may not be included, according to instructions to particular stations, or according to existing meteorological conditions. The third group is the Supplemental group.

(*c*) Should it happen that all of the data for a Universal group are missing, that group will be represented by five slants, /////. Should it happen that all of the data for the Supplemental group are missing, that group will be omitted from the message.

b. Symbol and group arrangement.—(1) IIwwD FPPTT CD_ChNV.

(2) IIwwD FPPTT.

c. Definition of letter symbols.

Symbol	*Data*
(1) *First group, IIwwD.*	
II	Index number of the station, the first 0 of the assigned index number being omitted. (Code table 43.)
ww	Weather at time of observation. (Code table 34.)
D	Direction from which the wind is blowing, coded to eight points of the compass. (Code table 22.)
(2) *Second group, FPPTT.*	
F	Force of the wind in the Beaufort scale at time of observation. (Code table 23a.)
PP	Atmospheric pressure reduced to sea level in "whole units" of millibars, the initial 9 or 10 for "hundreds" of millibars being omitted. (Code table 32.)
TT	Temperature of the air at the time of observation in whole degrees Fahrenheit.
(3) *Third group, CD_ChNV.*	
C	Form of predominating cloud. (Code table 33.)
D_C	Direction of predominating cloud. (Code table 21.)
h	Lowest height above the ground at which the total cloudiness present covers more than five-tenths of the sky. (Known as the ceiling, in the United States.) (Code table 20.)

Symbol	*Data*
N	Total amount of sky covered with clouds. (Code table 14.)
V	Horizontal visibility, or the greatest distance toward the horizon at which an object can be recognized by the unaided eye for what it is, or at which lights of known intensity can be seen at night. (Code table 15.)

d. Description of code elements.—(1) *Index numbers: II.*—(*a*) Stations in the Caribbean Sea and in Central America have assigned to them index numbers from 000 to 099. Drop the first figure (0) from the assigned index number; the last two figures are used in the coded reports as II.

(*b*) Stations which have not been assigned index numbers use slants ("X" or "/") in place of figures when coding the station identification symbol II or III, and precede the report with the station name spelled out in full.

(*c*) 000 to 024 are assigned to islands south of 20° north latitude. 025 to 049 are assigned to Cuba. 050 to 074 are assigned to islands north of 20° north latitude. 075 to 099 are assigned to Central America.

(2) *Weather: symbol ww.*—(*a*) The symbol "ww" (code table 34) represents the weather at the time of observation, except under certain conditions which are indicated in the code table.

(*b*) The weather represented by ww should not be at variance with other data in the report.

(*c*) Should more than one of the descriptions in the ww table be applicable to the weather at the time of observation, the description with the highest code number is used.

(*d*) For correct coding of present weather, the observer should also be informed as to the character of the weather which occurred during the hour prior to the time of observation.

(*e*) The code figures 20, 30, 40, 50, 60, 70, 80, and 90 (that begin their particular decade groups) are broadly descriptive and are used only when the observer is unable to determine which higher number in the appropriate decade group correctly describes the phenomena.

(*f*) When precipitation is not occurring at the time of observation, the appropriate code figure is selected from the figures 00 to 49.

(*g*) When precipitation is occurring at the time of observation, the appropriate code figure is selected from the code figures 50 to 99, inclusive.

(*h*) Code figures 00 to 19, inclusive, for ww are used only when no precipitation has occurred at the station during the hour preceding the time of observation.

(*i*) Code figures 20 to 29, inclusive, for ww are used only when precipitation has occurred during the hour preceding the time of observation and is not occurring at the time of observation.

(*j*) When ww is 00, symbol N is coded 0 or 1; when ww is 01, symbol N is coded 2, 3, or 4; when ww is 02, symbol N is coded 4, 5, or 6; when ww is 03, symbol N is coded 7 or 8. When symbol N is coded as 4 and present weather is coded as 01, the total amount of sky covered is five-tenths or less (scattered clouds). When symbol N is coded as 4 and present weather is coded as 02, the total amount of sky covered is more than five-tenths (broken sky coverage).

e. Wind: symbols D and F.—(1) *Symbol D, direction of wind.*—(*a*) Wind direction (code table 22) refers to the direction from which the wind comes.

(*b*) True (not magnetic) directions and true (corrected) velocities are coded. Wind direction is coded to eight points of the compass.

(*c*) When instruments recording to eight points of the compass are not available, the true direction of the wind as determined by the eye is coded.

(*d*) When the air has no perceptible motion (calm), code 0 is used for symbol D.

(2) *Symbol F, wind force.*—(*a*) Wind force (code table 23a) refers to the code for the Beaufort scale.

(*b*) When wind force at the time of the observation exceeds force 9, the figure 9 is coded for symbol F and a word is added in plain language at the end of the message, as follows: GALE (for force 10); STORM (for force 11); or HURRICANE (for force 12).

(*c*) When the air has no perceptible motion (calm), 0 is coded for F.

f. Pressure: symbol PP, atmospheric pressure reduced to sea level.—Barometric pressure represented by the symbol PP is the atmospheric pressure corrected for index error, temperature, and gravity and reduced to sea level. It is coded to the nearest whole millibar with the initial figure 9 or 10 (representing the "hundreds" millibars) omitted. (See code table 32.) Examples: 1025.7 mb. is coded 26; 981.4 mb. is coded as 81.

g. Temperature: symbol TT.—(1) temperatures are coded in whole degrees Fahrenheit, to the nearest whole degree.

(2) For temperatures of 100° or higher, the number 100 is subtracted from the actual temperature reading, and the numerical result is used. Example: 107° is coded 07; 100° is coded 00; 114° is coded 14.

h. Clouds: symbols C, D_C, h, and N.—(1) Symbol C represents the

form of predominating cloud, according to the International Cloud System. (See table 33.)

(*a*) When absolutely no clouds are present, the third group in the report will not be sent.

(*b*) The form of predominating cloud is the genus which is observed to cover the largest portion of the sky at the time of observation. All species or special forms of each cloud genus will be counted in determining the total amount of the sky covered by that genus.

(*c*) When it appears that there are two or more types of clouds which appear to cover an equal amount of sky, the higher type should be reported for symbol C.

(*d*) Observers should always have copies of publications illustrating cloud forms according to the International Cloud Atlas available either in pamphlet or sheet form, in order to refer to the pictures of the representative types of clouds when coding the type of cloud observed.

(2) Symbol D_C refers to the direction from which the predominant type of cloud is moving. (Code table 21.)

(*a*) When the coded cloud form has more than one direction, the direction of the highest position of the cloud form will be used for D_C.

(*b*) When the motion of the coded cloud form is so slow that a direction cannot be determined (calm), or is variable, the code figure 0 is used for D_C. When the direction is unknown, use figure 9 for D_C.

(3) Symbol h, height of ceiling (code table 20), represents the lowest height above the ground at which the total cloudiness present covers more than five-tenths of the sky. This height is the ceiling.

(*a*) Code figure 9 will be used for symbol h as follows: Whenever less than five-tenths of the sky is covered; whenever clouds above 10,000 feet, in any amount, are the only clouds observed; whenever clouds above 10,000 feet, in any amount, are observed along with lower clouds which cover less than five-tenths of the sky.

(*b*) Whenever the sky is five-tenths covered, or more, with clouds which are lower than 10,000 feet, a figure lower than 9 should be used for symbol h.

(*c*) Code figure 0 will be used for symbol h as follows: Whenever dense or thick fog is present; whenever heavy rain or blowing dust or sand prevent observation of the sky; whenever the base of clouds present is less than 150 feet above the station.

(*d*) Where instruments are not available, the height of the ceiling will be estimated. When ceilings are estimated and some doubt exists as to true height, it is believed advisable to report the lower rather than the higher value of the ceiling.

(4) Symbol N, amount of sky covered with clouds (code table 14), is based on the total visible amount of cloudiness, as projected against the dome of the sky, observed at the time of observation. The amount of coverage, compared with the amount of open sky, is determined by estimation. The amount of clouds represented by N should not be at variance with the present weather represented by ww in group IIwwD.

i. Visibility: symbol V.—(1) Visibility (code table 15) is coded as the greatest distance toward the horizon at which an object can be recognized, by the unaided eye, for what it is, or at which light of known intensity can be seen at night.

(2) When visibility is low in some directions and high in others at the time of observation, a code figure expressing the "average" visibility or prevailing visibility in all directions is used.

(3) Each station will have a table of visibility reference points showing the distances of various prominent objects suitable for determining the exact code value to be used for symbol V. This table should include objects suitable for determining visibility at night as well as by day.

(4) For determination of visibility during daylight hours, black or dark-colored objects against the sky are used. Light-colored objects and objects appearing against terrestrial backgrounds are not used.

(5) For determinations of visibility during the night, lights of known intensity at known distances are used wherever practicable. Airway beacons are not used, as they have great penetrating power and give values that are in excess of the standard values for symbol V.

(6) It is desirable for synoptic purposes that observations of identical conditions by different observers be identical, therefore the proper coding of visibility is extremely important. The coded visibility is a measure of the transparency of the air near the surface. Since the absence of daylight alone does not materially affect the visibility, observations made by day must be comparable with those at night. A large daily rise and fall of the values coded for visibility for hours of daylight and hours of darkness should be avoided.

j. Additional phenomena.—(1) When unusual weather or special phenomena occur which have a forecast significance, observers should add appropriate descriptive words in plain English or Spanish at the end of the message.

(2) The type of additional data needed varies with the seasons and according to the locations and exposures of the various stations. The

supervising stations will forward to each station special instructions on additional data to be included when unusual meteorological conditions are observed.

(3) When a tropical disturbance is known or suspected to exist in the general vicinity of the station, and the barometric pressure, wind direction or velocity, or other local conditions are appreciably affected thereby, special observations will be taken and forwarded in the same manner as regular observations.

(4) Additional information sometimes of considerable value to forecasters includes:

(*a*) Type, true direction, and velocity of clouds. Example: ALTOSTRATUS FROM NORTH NORTHWEST MOVING RAPIDLY.

(*b*) Swell and tide data from coastal stations. Example: HIGH TIDES AND MODERATE SWELL.

(*c*) Barometer change in the past 3 hours. Example: MINUS FOUR MILLIBARS LAST THREE HOURS.

(*d*) Wind fluctuations in the past 2 hours. If the wind direction is changing in a clockwise direction, it is said to be veering. If the wind direction is changing in a counter-clockwise manner, it is said to be backing. If the wind has been blowing steadily from the same point during the past 2 hours, the word STEADY is used. Example: WIND VEERING; or WIND BACKING.

(*e*) True wind direction. When the true wind direction is intermediate between any two of the eight cardinal points and the velocity is above 24 miles per hour, the intermediate direction should be reported. The observer who reports true wind directions often helps the forecaster locate the center of the disturbance more accurately. Example: WIND WEST NORTHWEST.

(*f*) Actual wind velocity. When the surface velocity has reached 75 miles or more, words indicating true velocity in miles per hour should also be included. The word HURRICANE is always sent when the Beaufort scale is 12, in special as well as in regular observations. Example: HURRICANE ONE HUNDRED FIVE MILES PER HOUR.

k. Stations using full weather code numeral system 1939.—There are several stations in the Caribbean which now use the full weather code numeral system 1939. This can be determined by inspection. Stations so reporting will be decoded as is described in the section describing the 1939 weather numeral code.

65. Weather code, numerical system of ships at sea.—*a. General.*—The International Code for weather reports from ships is a standard code to be used in reporting weather from ships designated to make reports.

(1) The standard code is composed of four groups of five figures each known as the universal data, and additional supplemental groups. Every report will include at least all of the universal data.

(2) There are three series of supplemental groups:

(*a*) Three groups of five figures each. The first number of the first supplemental group immediately following the universal data is a figure "3." The complete report will have seven groups of five figures each. This form is known as the "supplemental three" data.

(*b*) Two groups of five figures each. The first number of the first supplemental group immediately following the universal data is a figure "6". A complete report will have six groups. This type of a report is known as the "supplemental six" data.

(*c*) Two groups of five figures each, the first figure being a "9." A complete report will have six five-figure groups. This type of report is known as the "supplemental nine" data.

b. Symbol and group arrangement.—(1) Universal data: YQLLL lllGG DDFww PPVTT.

(2) Supplemental-three data: YQLLL lllGG DDFww PPVTT $3C_LC_MC_HN$ $T_dKD_kWN_h$ d_sv_sapp.

(3) Supplemental-six data: YQLLL lllGG DDFww PPVTT $6KD_KCN$ $T_dd_sAWC_H$.

(4) Supplemental-nine data: YQLLL lllGG DDFww PPVTT $9SKD_kW$ CNN_hAT_d.

c. Definition of letter symbols.

Symbol	*Data*
A	Amount and characteristic of barometric tendency expressed by a single figure. (Code table 28.)
a	Characteristic of barometric tendency during the 3-hour period ending at the time of observation. (Code table 27.)
C	Form of predominating cloud. International symbol. (Code table 33.)
C_L	Form of low cloud. (Code table 17.)
C_M	Form of middle cloud. (Code table 18.)
C_H	Form of high cloud. (Code table 19.)
DD	Direction of wind. True direction of wind near the surface coded to 16 points of the compass. (Code table 22.)
D_K	Direction, true, from which the swell is moving. (Code table 38.)
d_s	Direction of ship's course on scale 0–8. (Code table 38.)
F	Force of the wind on the Beaufort scale at the time of observation. Forces above 9 are reported as 9, with the actual force in a word at the end. (Code table 23a.)
GG	Greenwich mean time of observation, with the day beginning at midnight and the time reckoned from 0000 to 2400.
K	Swell in open sea. (Code table 40.)

Symbol	*Data*
K_d	Combines D_K and K into one symbol. See above.
LLL	Latitude in degrees and tenths, the tenths being obtained by dividing the number of minutes by 6 and neglecting the remainder.
lll	Longitude in degrees and tenths, the tenths being obtained as for latitude LLL. The hundreds digit "1" is omitted when the longitude is greater than 99.9°.
N	Total amount of sky covered with clouds. (Code table 14.)
N_h	Amount of low cloud. (Code table 14.)
PP	Pressure in whole millibars (initial 9 or 10 being omitted). The values refer to sea level and include all corrections for index error, temperature, and gravity. (Code table 32.)
pp	Amount of barometric tendency during the 3 hours preceding the time of observation expressed in units of one-fifth of a millibar. (Code table 29.)
Q	Octant of the globe in which the ship is located. (Code table 37.)
S	State of the sea. (Code table 42.)
TT	Temperature of the air in whole degrees Fahrenheit.
T_d	Difference between air and sea temperature. (Code table 39.)
V	Visibility, or distance at which objects can be seen in daylight (or at which lights can be seen at night). (Code tables 15 and 16.)
v_s	Speed of ship in knots. (Code table 41.)
W	Past weather. (Code table 35.)
ww	Actual weather at the time of observation. (Code table 34.)
Y	Day of the week. (Code table 36.)

66. Mexican code for reporting meteorological conditions.—*a. General.*—(1) The morning and evening observations consist of one group of three figures and seven groups of five figures each. Occasionally words in Spanish are used to indicate supplementary information, such as in the case of current wind velocities over force nine.

(2) The noon message consists of one group of three figures, and five groups of five figures each.

b. Universal data.—(YGG) IIINV DDFww PPPTT.

c. Supplemental data.—(1) Morning observations: ($D_dF_dD_xF_xF_x$) $P_mP_mP_mC_LC_M$ C_HD_cRRR ($T_nT_nT_mT_mW$).

(2) Noon observations: $P_mP_mP_mC_LC_M$ C_HD_cRRR.

(3) Evening observations: Same as the morning report, except that the last group is changed to ($T_nT_nT_xT_xW$).

d. Symbol and group arrangements of Mexican code.—(1) 0630 observation (90th-meridian Mexican time): (YGG) IIINV DDFww PPPTT ($D_dF_dD_xF_xF_x$) $P_mP_mP_mC_LC_M$ C_HD_cRRR ($T_nT_nT_mT_mW$).

(2) 1230 observation (90th-meridian Mexican time): (YGG) IIINV DDFww PPPTT $P_mP_mP_mC_LC_M$ C_HD_cRRR.

(3) 1830 observation (90th-meridian Mexican time): (YGG) IIINV DDFww PPPTT ($D_dF_dD_xF_xF_x$) $P_mP_mP_mC_LC_M$ C_HD_cRRR ($T_nT_nT_xT_xW$).

NOTE.—Groups shown in parentheses above are normally not retransmitted by the U. S. relaying station.

e. Definition of symbols.—Symbols III, N, V, DD, F, PPP, $P_mP_mP_m$, C_L, C_M, C_H, D_c are defined in the same manner as for the numerical code for weather 1939.

Symbol	*Data*
D_d	Direction of the prevailing wind in the last 12 hours, expressed to eight points of the compass. (Code table 21.)
D_x	Direction of maximum wind during the last 12 hours, expressed to eight points of the compass. (Code table 21.)
F_xF_x	Velocity of maximum wind during the last 12 hours, expressed in meters per second.
GG	Hour of the observation to the nearest hour on the 00-to-24-hour scale. Given in the 90th-meridian standard time. (Add two hours to reported value to get eastern war time.)
RRR	Amount of precipitation in whole millimeters; 12-hour amounts are reported in the 0630 and 1830 messages; 6-hour amounts are reported in the 1230 message. To convert to inches, divide the whole millimeters by 25.4.
TT	Temperature in whole degrees Fahrenheit at the time of observation. When temperature is below zero, 50 is added and the numerical sum is coded for TT. When the temperature is above 100°, 100 is subtracted from actual temperature and the difference is coded for TT.
T_mT_m	Mean temperature of the preceding day.
T_nT_n	Minimum temperature. In the 0630 message, T_nT_n is for the past 12 hours. In the 1830 message, T_nT_n is for the past 24 hours.
T_xT_x	Maximum temperature of the past 24 hours.
W	Past weather during the preceding 12 hours. (Code table 35.)
ww	Present weather (only the following code numbers of the complete ww table are used: 00, 01, 02, 03, 04, 10, 13, 17, 19, 50, 60, 70, 80, 90, and 99). (Code table 34.)
Y	Day of the week. (Code table 36.) (Sunday is 1, Monday 2, Saturday is 7, etc.)

67. Weather code, hourly airway reports *as transmitted by teletype and radio, or by telegraph and telephone.*—*a. General.*—For those stations on an airway and those instructed to report hourly weather reports, at least one report will be made each hour by a standard teletype, radio, telegraph or telephone report. Under special conditions outlined in the regulations for procedure in making observations, special reports may be made using the standard form of

report. Some stations off the regular airways have special instructions regarding the making of reports when certain meteorological conditions exist.

(1) The following will govern procedure in cases of failure of communications:

(*a*) In general, in event that the transmission of reports by radio or teletype is not practicable from any particular reporting station, due to failure of these facilities, the next hourly report following the breakdown will be telegraphed, using the check "WEA", or telephoned collect to another station on the airway which will be designated by the general supervising official to receive it, and thereafter at 25 minutes past the hours of 1 and 7, AM and PM, EST, so long as the failure continues. Hourly records will be kept as usual during such periods. "Special" observations will be telegraphed or telephoned as required by conditions. Special instructions may be given individual stations concerning the times and manner in which reports are to be made when failures occur.

(*b*) Stations rendering airway reports regularly by telephone or telegraph will follow the above procedure with regard to the entry of observations.

b. Elements of hourly weather sequence code.—(1) *Station designator.*—This is to be indicated by use of the proper group of two or three letters representing the name of the station at which the report originated. These letters are assigned by the Communications Division of the Civil Aeronautics Administration, Federal Airways Service. The lists appear in the Manual of Operations for the Communications Division.

(2) *Classification of report.*—This is to be indicated by use of one of the proper letters assigned for this purpose, when conditions at a controlled airport in a controlled zone fall within the classification standards. No classifying letter is sent by stations not in controlled zones. Air Corps weather stations will not enter the classification letter "C", "N", or "X", unless the station has been specifically designated by the Weather Bureau to classify its reports.

(3) *Type of report.*—This is to be indicated by the letters "SPL" meaning "special observation" when such a type of report is being transmitted. "Local extra" observations, the transmission of which is limited to local teletype circuits, will be indicated by "LCL". Observations are divided into four classes: (*a*) *Record observation.*—One record observation will be taken each hour at stations where teletype or radio are located during the period these facilities are

normally in operation. The observation shall be the one taken for use in the regular sequence beginning at 30 minutes past each hour. The observation for the report should not begin earlier than 20 minutes before the designated time of the observation. Ordinarily the record observation will be taken during the 10 minutes prior to its being placed in the sequence, except when special data, such as mercurial barometer readings, pressure changes, clouds, etc., are observed. These may be obtained prior to the 10-minute period. The use of ceiling balloons also will require extra time.

(*b*) *Special observations.*—Special observations are those taken when there is a marked change in weather conditions. Detailed instructions concerning special observations are given in instructions and regulations for making surface observations.

(*c*) *Local extra observations.*—Local extra observations shall be made at Army stations each 15 minutes following a "record," "check," or "special" observation which shows a ceiling of less than 1,000 feet, or a visibility of less than 3 miles, or whenever hazardous weather conditions exist or are anticipated within an hour. Local extra observations are made at Weather Bureau stations according to instructions given in Circular N. Local extra observations will include only the classification, ceiling, sky, visibility, weather, obstructions to vision, and remarks. The time of observation will be the time of filing the report, if it is filed either directly on the local teletype or interphone system, or by delivery to a Civil Aeronautics Administration communications station. When it is not filed, the time will be the time of completion of entry on Form No. 94. When an observation indicates a change from the reported values in the last "record" or "special" observation, and this change warrants a "special" report, a special report shall be filed and reported according to instructions for special reports. When a special observation is requested by an army or air line dispatcher, official, etc., and conditions do not warrant making a special observation, or if it is not the proper time to take a record observation, that observation shall be classified as a "local extra" and will be noted as LCL, not SPL.

(*d*) *Check observations.*—These are comparisons by actual observation of the present existing values of ceiling, sky, visibility, weather, obstructions to vision, wind, and altimeter setting with the last report, to ascertain if there has been a change in the weather conditions. A check observation is not reported by teletype. If a change has taken place, necessary changes must be made in the next report, or a special report must be made if the meteorological conditions warrant that report.

(*e*) *Record special.*—In preparing the record observation report for transmission, the time of observation and the type of report are omitted. However, if conditions exist such that a special observation would have been necessary and a special report made, the record observation will be termed a "record special," and will be designated in the teletype report as "SPL."

(4) *Time of report.*—This is indicated in special and local extra observations only, except that it is not indicated in SPL reports which are sent in regular scheduled hourly sequences. The time is a group of figures representing the time, on the 24-hour-clock system, followed without space or oblique by a letter representing the time zone in which the station rendering the report is located, e. g., "1354E" indicates 1:54 PM, EST.

(5) *Ceiling.*—(*a*) "Unlimited" ceiling is indicated by the absence of a symbol or figures for this element.

(*b*) The height of the ceiling up to and including 9,750 feet above the station is indicated by figures representing the proper number of hundreds of feet to and including 5,000 feet, and to the nearest 500 feet up to and including 9,750 feet; e. g., "35" indicates 3,500 feet.

(*c*) When the ceiling is zero, the figure zero (0) is to be used.

(*d*) When the ceiling height is estimated, the letter "E" for "estimated" is to be placed immediately preceding the ceiling-height figures.

(*e*) When a ceiling balloon is blown out of sight before reaching the clouds, a plus sign is to be entered preceding the ceiling figures which represent the last observed height of the balloon.

(*f*) When the ceiling is below 2,000 feet and is changeable with respect to height, this may be indicated by entering the letter "V" immediately following the ceiling value. For complete instructions, see the discussion on ceiling in section II.

(6) *Sky conditions.*—(*a*) Sky condition when observable is to be indicated by the following symbols:

Condition	*Symbol*
Clear	○
Scattered clouds (few to, and including, five tenths)	⦶
Broken clouds (six, to less than ten tenths)	⦷
Overcast (ten tenths coverage)	⊕
High scattered clouds	⦶/
High broken clouds	⦷/
High overcast	⊕/
High overcast, lower broken clouds	⊕/⦷
High overcast, lower scattered clouds	⊕/⦶
High broken, lower broken clouds	⦷/⦷

Condition	Symbol
High broken, lower scattered clouds	⦷/⦶
High scattered, lower broken clouds	⦶/⦷
High scattered, lower scattered clouds	⦶/⦶
Overcast, lower broken clouds	⊕⦷
Overcast, lower scattered clouds	⊕⦶
Broken, lower broken clouds	⦷⦷
Broken, lower scattered clouds	⦷⦶
Scattered, lower broken clouds	⦶⦷
Scattered, lower scattered clouds	⦶⦶

(*b*) A slant line following a symbol in the above table indicates that the clouds are 10,000 feet or more above the ground.

(*c*) The plus sign (+) or minus sign (−) preceding cloudiness symbols is used to indicate "dark" or "thin", respectively.

(*d*) Whenever the "scattered clouds" symbol occurs as the only symbol, or as the last symbol in a sky condition report, and such scattered clouds are less than 10,000 feet above the ground, the height of such scattered clouds is to be indicated by insertion of the proper figure or figures preceding the symbol, without space of oblique. The height of the scattered clouds up to and including 9,750 feet above the station is indicated by figures representing the proper number of hundreds of feet to and including 5,000 feet, and to the nearest 500 feet up to and including 9,750 feet; e. g., "35" indicates 3,500 feet. The height of scattered clouds is always estimated, but the letter "E" is never used to indicate this fact.

(*e*) When the sky condition cannot be determined, due to the presence of dense fog, thick dust, heavy rain, heavy snow, etc., or any combinations of precipitation and obstructions to vision, no report of the sky condition, as such, will be made. The reason for the omission in such cases will be apparent from the weather and/or obstructions to vision reported.

(7) *Visibility.*—(*a*) Visibility of 10 miles or more is to be indicated by the absence of a value for this element. If between 9 and 10 miles, the visibility is reported as 9 miles. When the visibility is omitted from a report, this element is broadcast by Civil Aeronautics Administration radio operators as "visibility more than 9 miles" and should be so interpreted when reading airway weather reports. This interpretation in no way affects the rule that a visibility of more than 9 miles but less than 10 will be recorded as 9 in the report.

(*b*) Visibilities from zero up to but not including 10 miles are to be indicated by the proper figures representing the values in miles and/or fractions thereof. Standard visibility values are discussed in section II.

(c) If the visibility is two miles or less and is changeable or fluctuating, this may be indicated by entry of the letter "V" immediately following the value. For complete instructions, see the discussion of visibility in section II.

(d) Visibility is reported as 0, ⅛, ⅕, ¼, ½, ¾, 1, 1¼, 1½, 1¾, 2, 2¼, 2½, 3, 4, 5, etc. If halfway between two values, use the smaller, if over halfway between two values, use the larger, except between 9½ and 10 miles. In this case use 9 miles.

(e) Visibility values less than 7 miles must be explained by a weather element and/or obstruction to vision.

(8) *Weather.*—The weather element in a report is indicated by the following symbols:

Symbol	*Character*	*Limits*	*Vis. values reported*
R−	Light rain	Trace up to 0.01 inch in 6 minutes.	
R	Moderate rain	Over 0.01 inch up to and including 0.03 inch in 6 minutes.	
R+	Heavy rain	Over 0.03 inch in 6 minutes	
RW−	Light rain showers	Same as R−	
RW	Moderate rain showers	Same as R	
RW+	Heavy rain showers	Same as R+	
ZR−	Light freezing rain	Same as R−	
ZR	Moderate freezing rain	Same as R	
ZR+	Heavy freezing rain	Same as R+	
S−	Light snow	Vis. ⅝ mi. or more	¾ mi. or more
S	Moderate snow	Vis. 5/16 mi. but not ⅝	½ mile
S+	Heavy snow	Vis. less than 5/16	0, ⅛, ⅕, ¼ mi.
SP−	Light snow pellets	Same as S−	Same as S−
SP	Mod. snow pellets	Same as S	Same as S
SP+	Heavy snow pellets	Same as S+	Same as S+
SW−	Light snow showers	Same as S−	Same as S−
SW	Moderate snow showers	Same as S	Same as S
SW+	Heavy snow showers	Same as S+	Same as S+
L−	Light drizzle	Vis. 1¼ mi. or more	1¼ mi. or more
L	Moderate drizzle	Vis. over ⅝ mi. but not 1¼ mi.	¾, 1 mi.
L+	Heavy drizzle	Vis. 5/16 but not ⅝ mi.	½ mile
ZL−	Light freezing drizzle	Same as L−	Same as L
ZL	Mod. freezing drizzle	Same as L	Same as L
ZL+	Heavy freezing drizzle	Same as L+	Same as L+
E−	Light sleet	No accumulation on ground	
E	Moderate sleet	Slight accumulation on ground.	
E+	Heavy sleet	Heavy accumulation on ground.	
A−	Light hail	Same as E−	

Symbol	Character	Limits	Vis. values reported
A	Moderate hail	Same as E	
A+	Heavy hail	Same as E+	
AP−	Light small hail	Same as E−	
AP	Moderate small hail	Same as E	
AP+	Heavy small hail	Same as E+	
SQ−	Mild snow squall	Wind gusts of 24 mph or less.	
SQ	Moderate snow squall	Wind gusts between 24 and 39 mph.	
SQ+	Severe snow squall	Wind gusts over 39 mph.	
RQ−	Mild rain squall	Same as SQ−	
RQ	Moderate rain squall	Same as SQ	
RQ+	Severe rain squall	Same as SQ+	
T	Thunderstorm	(1) Occasional or fairly frequent flashes of lightning; (2) weak to loud peals of thunder; (3) rainfall, if any, may be light, moderate, or possibly heavy; (4) hail, if any, is light or moderate; (5) wind with passage of storm overhead or in close proximity does not exceed 40 mph; (6) temperature drop, if any, with passage of storm overhead or in immediate vicinity is not usually as pronounced as in case of heavy thunderstorm.	
T+	Heavy thunderstorm	(1) Nearly incessant sharp lightning; (2) loud peals of almost continuous thunder; (3) heavy rain; (4) hail, if any, is light, moderate, or heavy; (5) wind, with passage of storm overhead or in close proximity, does exceed 40 mph; (6) rapid temperature drop, possibly as much as 20° in 5 mins. in connection with storm overhead or in immediate vicinity.	
TORNADO		Always to be written out in full.	

NOTE.—The symbols SP−, SP, and SP+ will never be interpreted as sprinkling.

(9) *Obstructions to vision.*—The following symbols will be used when appropriate:

Symbol	*Character*	*Limits*	*Vis. values reported*
F−−	Damp haze	Vis. 6 mi. or less	6 mi. or less.
F−	Light fog	Vis. 5/8 mi. to 6 mi	3/4 mi. to 6 mi., inclusive.
F	Moderate fog	Vis. 5/16 but not 5/8 mi	1/2 mi.
F+	Thick fog	Vis. 1/8 but not 5/16 mi	1/5, 1/4 mi.
FF	Dense fog	Vis. less than 1/8 mi	0, 1/8 mi.
GF−	Light ground fog	Same as F−	Same as F−.
GF	Moderate ground fog	Same as F	Same as F.
GF+	Thick ground fog	Same as F+	Same as F+.
GFF	Dense ground fog	Same as FF	Same as FF.
IF−	Light ice fog	Same as F−	Same as F−.
IF	Moderate ice fog	Same as F	Same as F.
IF+	Thick ice fog	Same as F+	Same as F+.
IFF	Dense ice fog	Same as FF	Same as FF.
H	Hazy (dry haze)	Vis. 6 mi. or less	6 mi. or less.
K−	Light smoke	Vis. 1 1/4 mi. to 6 mi	1 1/4 mi. to 6 mi., inclusive.
K	Moderate smoke	Vis. 5/8 mi. but less than 1 1/4 mi.	3/4, 1 mi.
K+	Thick smoke	Vis. less than 5/8 mi	0, 1/8, 1/5, 1/4, 1/2 mi.
D−	Light dust	Same as K−	Same as K−.
D	Moderate dust	Same as K	Same as K.
D+	Thick dust	Same as K+	Same as K+.
BD−	Light blowing dust	Same as K−	Same as K−.
BD	Moderate blowing dust	Same as K	Same as K.
BD+	Thick blowing dust	Same as K+	Same as K+.
BN−	Light blowing sand	Same as K−	Same as K−.
BN	Moderate blowing sand	Same as K	Same as K.
BN+	Thick blowing sand	Same as K+	Same as K+.
BS−	Light blowing snow	5/8 mi. to 6 miles	3/4 mi. to 6 mi., inclusive.
BS	Moderate blowing snow	Same as S	Same as S.
BS+	Thick blowing snow	Same as S+	Same as S+.
GS−	Light drifting snow	Same as BS−	Same as BS−.
GS	Moderate drifting snow	Same as S	Same as S.
GS+	Thick drifting snow	Same as S+	Same as S+.

(10) *Barometric pressure.*—The barometric pressure is to be indicated by a group of three figures, the first two of which represent the tens and units of millibars and the last of which represents the tenths of a millibar involved. The hundreds digit, a 9 or 10, is omitted. Pressure is the atmospheric pressure corrected for instrumental errors, temperature, and gravity. It is then reduced to sea level.

(11) *Temperature.*—This is to be indicated in figures giving its value to the nearest degree Fahrenheit. In teletyping a report for values

below zero, a minus sign precedes the value. In a telephone or telegraph report, the word "minus" is spelled out.

(12) *Dew point.*—This is to be indicated in figures, giving its value to the nearest degree Fahrenheit. When sent, it follows the temperature and is separated therefrom by an oblique (slant mark). The same rule applies for negative temperatures of dew point as for those in reporting temperature values.

(13) *Wind.*—(*a*) *Direction.*—Wind direction is to be indicated as follows:

North.	South.
North-northeast.	South-southwest.
Northeast.	Southwest.
East-northeast.	West-southwest.
East.	West.
East-southeast.	West-northwest.
Southeast.	Northwest.
South-southeast.	North-northwest.

(*b*) *Velocity.*—The velocity is to be indicated by figures representing its value in miles per hour. Calm is indicated by the letter "C" with no indication of direction. If estimated, this is to be indicated by the entry of the letter "E" immediately following the figures, without space or oblique.

(*c*) *Character.*—The character of the wind is to be indicated, when appropriate, by entry of the following symbols immediately following the velocity without space or oblique; fresh gusts, "—"; strong gusts, "+."

(*d*) *Wind shifts.*—Wind shifts are to be indicated by entry immediately following the last element of the wind data of the report, by use of a direction arrow showing the direction of wind prior to the shift, to eight points of the compass, followed by the local time, the local time zone, and an indication of the intensity by entry of minus or plus signs for "mild" and "severe," respectively. Moderate wind shift is indicated by the absence of a plus or minus sign.

(*e*) *Altimeter setting.*—This is to be indicated by a group of three figures, the first of which will represent the inch and the last two will represent the number of hundredths of an inch of the pressure setting for sensitive altimeters. When sent, it follows the wind element of the report, and is separated therefrom by an oblique (slant mark). No oblique line follows the altimeter setting unless followed by remarks or additional data.

(*f*) *Remarks.*—Remarks are to be entered by use of proper symbols and authorized abbreviations. When sent, remarks are separated from the preceding element by an oblique. (See section on teletype procedure, for authorized abbreviations to be used in remarks.)

(14) *Special 6-hourly data added to sequence-collection reports.*—(*a*) The numeral group, "app(R)(R)RR" will be added to the end of the 0130 EST, 0730 EST, 1330 EST, and 1930 EST teletype and radio hourly sequence-collection reports at all hourly reporting stations equipped with pressure-measuring instruments and rain gage, which are not required to render the numerical map code reports.

(*b*) The symbols "a, pp, RR" have the same connotation as for the International Numerical Map Code. "a" is the pressure characteristic of change during the 3 hours preceding the time of observation. "pp" is the amount of pressure change in fifths of millibars. "RR" is the amount of water-equivalent precipitation since the last 0730 EST observation, in hundredths of inches. For excessive amounts of precipitation (over 0.99 inch), (R) or (R)(R) are prefixed to the hundredths to show units of inches as well as hundredths of an inch. 10.52 inches would be coded as 1052. A trace will be reported only once as 00 for RR. If no precipitation has occurred during the prescribed measuring period, the group "app" is sent and the precipitation groups are omitted. Measuring periods are:

1330 EST observation	Total in past 6 hours.
1930 EST observation	Total in past 12 hours.
0130 EST observation	Total in past 18 hours.
0730 EST observation	Total in past 24 hours.

(*c*) In addition to the pressure characteristic, pressure change, and rainfall amount group, stations specifically designated by the general supervising stations will add, after the "app(R)(R)RR" group, one or more of the following numeral code groups of the International Numerical Code: $C_LC_MC_HhD_C$, $7P_MP_MP_Ma_1$, T_nT_n, or T_xT_x. At stations designated to add the maximum temperature group T_xT_x or the minimum temperature group T_nT_n, the following time period covered by the maximum or minimum temperatures will determine the values to be reported:

1330 EST observation	T_nT_n 18-hour minimum.
1930 EST observation	T_xT_x 12-hour maximum.
0130 EST observation	T_xT_x 18-hour maximum.
0730 EST observation	T_nT_n 12-hour minimum.

The meteorological significance of the code elements is the same as in the International Numerical Map Code.

Symbol	*Data*
C_L	Type of low cloud.
C_M	Type of middle cloud.
C_H	Type of high cloud.
h	Ceiling.
D_C	Direction on an eight-point scale of the middle cloud if there is any; or direction of the high cloud if there is no middle cloud; or direction of the low cloud if there are no middle and high clouds.
$P_MP_MP_M$	Pressure reduced to the 5,000-foot level above sea level.
a_1	Pressure characteristic of the 3-hour period ending 3 hours before the time of observation.
T_nT_n	Minimum temperature.
T_xT_x	Maximum temperature.

The additional data will be separated from the "remarks" by a slant line followed by a space.

(15) *Data to be added at 3-hourly periods.*—(*a*) Special data will be added to radio and teletype sequence reports for 0430 EST, 1030 EST, 1630 EST, and 2230 EST, as follows: Stations on the airways teletype or radio circuits which are equipped with pressure-measuring instruments will add the "app" code group representing the 3-hourly pressure change and characteristic. Such of these stations as have been instructed to do so will also add the code group $C_LC_MC_HhD_C$, representing cloud data. These groups will be added immediately following any remarks and will be separated from the regular sequence report by a slant mark (/) and one space. This slant mark will be added to the last figure group, symbol group, or word, according to which occurs last in the regular report.

(*b*) Stations not on the teletype circuits, which have been designated to do so, will telegraph reports at 0430 EST, 1030 EST, 1630 EST, and 2230 EST using the data for the first five groups in the Numerical Weather Code (the universal data and the cloud group: IIINV DDFww PPPTT $T_sT_s$app $C_LC_MC_HhD_C$) and a three-figure group $6R_cR_t$. The group "$6R_cR_t$" will be sent when precipitation or a thunderstorm has occurred since the observation taken 3 hours previously. The amount of precipitation will not be included in this latter group, and the group $6R_cR_t$ will contain only three numbers.

c. Grouping of symbols in teletype and radio transmissions.—(1) Transmission of the reports in symbols by teletype or radio shall be in the order shown below.

(*a*) Station designator (one space).

(*b*) Classification letter if sent[1] (one space).

[1] Sent only by stations at controlled airports within controlled zones.

(*c*) Type of report [2] (one space).

(*d*) Time of report [2] (one space).

(*e*) Ceiling,[3] sky,[4] visibility,[5] weather,[6] obstructions to vision,[6] sent as one group followed by one space without slant line.

(*f*) Barometric pressure,[7] temperature, dew point, wind and wind shifts, altimeter setting,[7] and remarks in symbols and authorized abbreviations, sent as one group. Slant lines will follow, without space, the pressure, the temperature, wind speed (unless gustiness or a wind shift has occurred, in which case the slant is omitted and follows the gustiness symbol or the time of the wind shift), the altimeter setting (unless there are no remarks, in which case no slant follows the altimeter setting), and remarks (only when the groups for additional data are added by stations which are instructed to include that data in the 0130 EST, 0430 EST, 0730 EST, 1030 EST, 1330 EST, 1630 EST, 1930 EST and 2230 EST reports).

(*g*) The groups app(R)(R)RR (preceded by one space), $C_LC_MC_HhD_C$ $7P_MP_MP_Ma_1$, and T_nT_n or T_xT_x when authorized. These groups are separated by one space without slant lines.

(2) Elements normally sent, but for some reason missing from the teletype or radio transmission, will be indicated by the letter "M" entered in the report in place of the missing data.

(*a*) Stations regularly not reporting certain elements will omit those elements, the order of the report being kept the same. For example, if the dew point is not sent, the temperature will be followed by the wind, etc.

(*b*) If there is an unlimited ceiling, a visibility of 10 miles or more, an absence of weather, or an absence of obstructions to vision, the places in which the values or authorized symbols for these elements occur will not be indicated by an "M," but the values or symbols will be omitted.

(3) Examples: (*a*) CG X SPL 1612C E3V 1/2VS 982/28/26 20+/945/SNW+OCNLY⊕. Explanation: The station is Chicago; the airport is closed; this is a special report at 4:12 PM, CST; ceiling is estimated 300 feet and is variable; the sky is overcast; there is a visibility of one-half mile which is variable; there is moderate snow (which is not at variance with the visibility value reported); there are no

[2] Given only in cases of special and local extra observations.

[3] Absence of a value for ceiling indicates that it is unlimited.

[4] Absence of sky-conditions symbols indicates that the true condition of the sky is not observable owing to presence of intense types of precipitation and/or obstructions to vision.

[5] Absence of a value for "visibility" indicates that this is 10 miles or more.

[6] Absence of an entry indicates these elements as not occuring.

[7] Sent only from stations equipped with mercurial barometers.

obstructions to vision except snow; the sea-level pressure is 998.2 millibars; the temperature is 28° F., and the dew point is 26° F.; the wind is from the northeast with a velocity of 20 miles per hour, with strong gusts of more than 24 miles per hour at the peak of the velocity; the altimeter setting is 29.45 inches; and there is occasionally heavy snow.

(*b*) GI ○1/8GFF 204/59/59C/014. Explanation: The station is Grand Island, Nebraska; the station is not at a controlled airport; this is the regular hourly sequence report so no "type of report" nor time is required; the ceiling is unlimited; the sky is clear; the visibility is one-eighth mile; there is no weather to report; the visibility is obstructed by dense ground fog (which is not at variance with the visibility value reported); the pressure reduced to sea level is 1020.4 millibars; the temperature and dew point are both 59° F.; there is no wind and the expression "calm" is used; the altimeter setting is 30.14 inches; and there are no remarks or additional data.

(*c*) WA N SPL 1624E E30⊕15⊖2VTRW–BO– 152/68/60→↘ 22+ ↑1618E/996/+NW OCNL LTNG IN CLDS. Explanation: The station is Washington, D. C.; the station is a controlled airport, the N standing for the requirement that pilots observe instrument flight rules; this is a special report at 4:24 PM, EST; the ceiling is estimated as 3,000 feet; the sky is overcast with low scattered clouds (which cover five-tenths or less of the sky) at 1,500 feet above the surface of the earth; the visibility is 2 miles and is variable; there is a thunderstorm with light rain showers; the obstruction to vision is light blowing dust (which is not at variance with the visibility reported); the atmospheric pressure reduced to sea level is 1,015.2 millibars; the temperature is 68° F.; the dew point is 60° F.; the wind is from the west-northwest with a speed of 22 miles per hour and strong gusts; at 4:18 PM, EST a moderate wind shift from the south to the present direction occurred; the altimeter setting is 29.96 inches; and it is dark in the northwest with occasional lightning in the clouds.

(*d*) BV E50⊕40⊖ 163/43/36↗4/999/STMG MTNS NE/ 301 57075 74526 45. Explanation: The station is Buffalo Valley, Nevada, and is not a controlled airport; the report is for a record observation so the type of report is omitted; the time of the report is omitted because it is for a record observation (taken at an assumed time of 1930 EST); the ceiling is estimated to be 5,000 feet; the sky is overcast with scattered clouds which cover not more than five-tenths of the sky at an elevation of 4,000 feet above the surface; the visibility is ten miles or greater; there are no weather nor obstructions to vision to

report; the atmospheric pressure reduced to sea level is 1,016.3 millibars; the temperature is 43° F., and the dew point is 36° F.; the wind is from the southwest with a velocity of 4 miles per hour; the altimeter setting is 29.99 inches; it is storming in the mountains to the northeast of the station; there has been a steady increase in pressure of a net amount of two-tenths millibars during the last 3 hours; the lower clouds are stratocumulus clouds, and the middle clouds are altocumulus, associated with altostratus or altostratus with a partially altocumulus character, coming from the southwest; the atmospheric pressure reduced to the 5,000-foot level above the level of the sea is 845.2 millibars; the atmospheric pressure decreased, then was steady, or fell with a slower rate towards the last part of the 3-hour period which ended 3 hours previous to the time of observation; and the maximum temperature during the last 12 hours was 45° F.

d. Method of telephoning or telegraphing reports.—(1) *Telegraph.*—(*a*) All words will be spelled out.

(*b*) The station name and the time of filing in cases of "special" observations will not be included in the body of the message, since these will be indicated in the message as transmitted by the telegraph company.

(*c*) Separate groups of five figures or less may be sent as one word in telegraphed messages. Therefore, figures in groups of five or less shall be used wherever possible in transmitting numerical values of data in the reports. However, the word "minus" must be used preceding the temperature and/or dew point figures to indicate below zero values. Fractions can be sent in a figure group by use of a slant mark (oblique); the slant mark is counted as one figure of the group.

(*d*) The word "clouds" will not be sent when giving the sky conditions. For example, "broken clouds" would be sent as "broken"; "high broken, lower scattered clouds" as "high broken lower scattered"; etc.

(*e*) Any element, ordinarily included in reports from a particular station, which cannot be determined for use in a particular report because of broken or defective instruments or other causes, will be indicated by the word "missing," inserted at the proper point in the message.

(*f*) Stations regularly not reporting certain elements will omit these, the order of the report being kept the same. For example, if the dew point is not included, the temperature will be followed by the wind, etc.

(*g*) Examples of telegraphed reports:

Observation, made at Albuquerque, New Mexico

Ceiling estimated 200 feet; sky overcast; visibility one-half mile; heavy thunderstorm; heavy hail; heavy rain; barometric pressure 999.1 millibars; temperature 75°; dew point 73°; wind west, 30 miles per hour, strong gusts; moderate southeast wind shift at 12:15 AM, EST; thunderstorm moving east.

As sent by telegraph

"Estimated 200 overcast ½ heavy thunderstorm heavy hail heavy rain 9991 7573 west 30 strong gusts moderate southeast wind shift 0015 eastern standard thunderstorm moving east."

As sent by teletype

AB E2 1/2T+A+R+ 991/75/73 30+ 0015E/T MOVG E

Observation, made at Albuquerque, New Mexico

Ceiling unlimited; clear; visibility one-eighth mile; dense ground fog; barometric pressure 1020.4 millibars; temperature 59°; dew point 59°; wind calm.

As sent by telegraph

Clear ⅛ dense ground fog 10204 5959 calm.

As sent by teletype

AB 1/8GFF 204/59/59C

Observation, made at Kansas City, Missouri

Classification, airport closed to operations; ceiling 400 feet, variable; sky overcast, lower scattered clouds at 200 feet; visibility 1½ miles, variable; light freezing rain; light fog; barometric pressure 1002.2 millibars; temperature 31°; dew point 31°; wind east, 12 miles per hour; altimeter setting 29.60 inches.

As sent by telegraph

Closed 400 variable overcast lower scattered 200 1½ variable light freezing rain light fog 10022 3131 east 12 2960.

As sent by teletype

KC X 4V⊕2⦶11/2VZR−F− 022/31/31 12/960

(2) *Telephone.*—When reports are telephoned to telegraph offices, they will be telephoned in exactly the same form as outlined for reporting by telegraph. When, however, they are telephoned direct to some terminal station for use there, they will be given in the proper order of elements with inclusion of the specific names of elements as may be required for making the report clear to the one receiving it. No specific rules for making the report clear can be cited here. It is necessary that the receiver of the report understands it. There should be no difficulty for the two people concerned in arranging a proper system to accomplish this.

e. Unscheduled airway reports.—Airway weather reports from points not located on a communication circuit may be offered for transmission at irregular or infrequent intervals. Such reports will be known as "unscheduled reports" and should be transmitted in the first available star schedule according to the Communications Division, Federal Airways Service, Civil Aeronautics Administration.

CODE TABLE 1.—*Code for* P_1P_1 *and* P_2P_2 *when unknown in apobs*

When the height and pressure at the base of the cloud layer are unknown: Code P_1P_1 as—	When the height and pressure at the top of the cloud layer are unknown: Code P_2P_2 as—
05—If uncertain whether base is below or above maximum (i.e., maximum elevation reached by airplane).	05—If uncertain whether top is below or above maximum.
06—If certain base is below maximum, plane being out of clouds at maximum.	06—If certain top is above maximum, plane being out of clouds at maximum.
07—If certain base is below maximum, plane being in clouds at maximum.	07—If certain top is above maximum, plane being in clouds at maximum.
08—If certain base is above maximum.	08—If certain top is below maximum.

CODE TABLE 2.—*Symbol* h_D—*Basis for information regarding cloud limits*

Code figure	Significance	Code figure	Significance
0	Base of clouds above maximum, top above maximum.[1] ($P_1P_1=08$, $P_2P_2=06$)	4	Base estimated, top observed.
		5	Base estimated, top estimated.
		6	Base estimated, top unknown.[1]
1	Base observed, top observed.	7	Base unknown, top observed.[1]
2	Base observed, top estimated.	8	Base unknown, top estimated.[1]
3	Base observed, top unknown.[1]	9	Base unknown, top unknown.[1]

[1] See code table 1.

CODE TABLE 3.—*Symbol* w_3—*Special phenomena*

Code figure	Phenomena	Code figure	Phenomena
0	Rime or frost.	5	Drizzle (international definition).
1	Hard ice.		
2	Haze or smoke.	6	Rain.
3	Dust or blowing snow (or both).	7	Snow or sleet, i. e., ice pellets.
		8	Hail.
4	Fog.	9	Thunderstorm [1] heard at station, or turbulence.

[1] See code table 5, last two sentences.

CODE TABLE 4.—*Symbol* w_4—*Icing*

Code figure	Phenomena
1	When there is a decrease, either sudden or gradual, in the ascensional rate which extends over two or more adjacent contacts, provided that the decrease occurs in a layer wherein the meteorological conditions are favorable for icing.
2	When meteorological conditions are favorable for icing, but the record shows either no decrease in ascensional rate, or an increase in ascensional rate of the balloon. (In this case icing and turbulence might be occurring simultaneously, such as is possible in the upper portion of a high cumulonimbus cloud. Here the ascending currents would be sufficiently strong to overcome or compensate retardation in the ascensional rate which would have resulted if icing only had occurred.)
3	When there is a decrease, either sudden or gradual, in the ascensional rate of the balloon with temperature 0° C. or lower (allowing for possible instrumental error), but the observer is unable to determine whether or not the instrument was in a cloud or in precipitation in liquid form and, therefore, whether icing occurred. (The decrease in ascensional rate in this case might be due to ice accretion in a cloud or precipitation aloft not visible to the observer. It is also possible to have a decrease in ascensional rate with conditions unfavorable for icing due to a descending turbulent current, to precipitation or to some mechanical defect.)

CODE TABLE 5.—*Code for* P_3P_3 *and* P_4P_4 *when unknown, or there was no emergence from phenomenon during ascent in apobs*

In those cases where, during the ascent, the airplane encountered one of the phenomena designated by the code element w_3, and the pressure at the level of entry (P_3P_3) into the phenomenon is unknown, or the pressure at the level of emergency (P_4P_4) from the phenomenon is unknown, or there was no emergence during the ascent, the code element P_3P_3 or P_4P_4, whichever is in question, will be coded as follows:

05—If uncertain whether the specified phenomenon was being encountered at the maximum elevation reached by the airplane.

06—If the specified phenomenon was encountered below the maximum elevation reached by the airplane, but not at that elevation.

07—If the specified phenomenon was being encountered at the maximum elevation reached by the airplane.

When w_3 represents "thunderstorm heard at station" (code figure 9), the elements $P_3P_3P_4P_4$ are coded as 0000 in apobs and also in raobs. When w_3 represents "turbulence" (code figure 9), the regular code for P_3P_3 and P_4P_4 will be used as for code figures 0 to 8 pertaining to w_3.

Code Table 6.—*Second group of "no raob" and "no apob" messages*

Group		Reason for no report
RA=radiosonde	AP=airplane	
RAWE	APWE	Unfavorable weather conditions.
RARF	------------	Recorder failure.
RAIF	------------	Radiosonde instrument failure.
RADI	------------	Radiosonde instrument disabled in launching.
RARA	------------	No radiosondes on hand.
RABT	------------	No batteries on hand.
RABA	------------	No balloons on hand.
RAHE	------------	No gas on hand.
RALO	APLO	Maximum altitude less than 500 m. above ground.
RADL	APDL	Observation delayed; to be transmitted later.
RAFI	APFI	No raob or apob message received for filing.
------------	APAF	Aerometeorograph failure.
------------	APPL	No airplane available.
------------	APPI	No pilot available.
------------	APFD	Field unsafe, or closed.
RAXX	APXX	Any reason not included above.

Code Table 7.—*Reasons for termination of raobs, the maximum altitudes of which are not more than 6,000 meters, m. s. l.*

Code group	Reason	Code group	Reason
GEFA	Ground equipment failure.	FADE	Fading, reason unknown.[1]
RAFA	Radiosonde transmitter failure.	WSUN	Weak, signal, reason unknown.[1]
BAFA	Radiosonde battery failure.	SHDR	Excessive shifting or drifting of the record.
POFA	Power failure at ground.	ICNG	Balloon forced down by icing conditions.
AINT	Atmospheric interference.	RAIN	Balloon forced down by heavy rain.
LINT	Local interference.	SNOW	Balloon forced down by heavy snow.
FAWI	Fading caused by high winds aloft.[1]	HAIL	Balloon forced down by hail.
WSAN	Fading signal, antenna shielded by obstruction.[1]	LKBL	Leaking balloon.
WSGE	Fading signal, geographical conditions.[1]	REXX	Any reason not included above.

[1] Fading signals differ from weak signals in that the former are first received satisfactorily, then become increasingly weaker, and finally become too weak for reception, while the latter are weak from the beginning.

Code Table 8.—*Potential temperatures for which stream functions and actual condensation pressures are to be computed, and dates on which each group become effective*

Date effective	Potential temperatures			Date effective	Potential temperatures		
	Lowest θ_x	Intermediate θ_y	Highest θ_z		Lowest θ_x	Intermediate θ_y	Highest θ_z
Jan. 1	290	296	302	Sept. 1	302	308	314
Mar. 1	296	302	308	Nov. 1	296	302	308
May 1	302	308	314	Jan. 1	290	296	302
July 1	308	314	320				

Code Table 9.—*Pressure, in mb., at various geometric heights above sea level, in hundreds of meters, according to U. S. standard atmosphere*

Geometric height, hundreds of meters above sea level	0	1	2	3	4	5	6	7	8	9
	mb.	*mb.*	*mb.*	*mb.*	*mb.*	*mb.*	*mb.*	*mb.*	*mb.*	*mb.*
−0	1, 013	1, 025	1, 038	1, 050						
+0	1, 013	1, 001	989	978	966	955	943	932	921	910
10	899	888	877	866	856	846	835	825	815	805
20	795	785	775	766	756	747	737	728	719	710
30	701	692	683	675	666	658	649	641	633	624
40	616	608	600	593	585	577	570	562	555	547
50	540	533	526	519	512	505	498	491	485	478
60	472	465	459	453	446	440	434	428	422	416
70	410	405	399	393	388	382	377	372	366	361
80	356	351	346	341	336	331	326	321	317	312
90	307	303	298	294	289	285	281	277	272	268
100	264	260	256	252	248	245	241	237	233	230
110	226	223	219	216	212	209	206	203	200	196
120	193	190	187	185	182	179	176	173	171	168
130	165	163	160	158	155	153	151	148	146	144
140	141	139	137	135	133	131	129	127	125	123
150	121	119	117	115	113	112	110	108	107	105
160	103	102	100	99	97	96	94	93	91	90
170	88	87	86	84	83	82	80	79	78	77
180	76	74	73	72	71	70	69	68	67	66
190	65	64	63	62	61	60	59	58	57	56
200	55. 2									
210	47. 2									
220	40. 4									
230	34. 5									
240	29. 5									
250	25. 2									
260	21. 6									
270	18. 4									
280	15. 8									
290	13. 5									
300	11. 5									

CODE TABLE 10.—*Heights above sea level, in hundreds of meters, at various pressures, in mb., according to U. S. standard atmosphere*

Pressure (mb.)	0	10	20	30	40	50	60	70	80	90
	100's m.	*100's m.*	*100's m.*	*100's m.*	*100's m.*	*100's m.*	*100's m.*	*100's m.*	*100's m.*	*100's m.*
1,000	1. 1	0. 3	−0. 6	−1. 4	−2. 2	−3. 0	------	------	------	------
900	9. 9	9. 0	8. 1	7. 2	6. 3	5. 4	4. 5	3. 7	2. 8	2. 0
800	19. 5	18. 5	17. 5	16. 5	15. 5	14. 6	13. 6	12. 7	11. 7	10. 8
700	30. 1	29. 0	27. 9	26. 8	25. 7	24. 6	23. 6	22. 5	21. 5	20. 5
600	42. 0	40. 8	39. 5	38. 3	37. 1	35. 9	34. 7	33. 5	32. 4	31. 2
500	55. 7	54. 3	52. 8	51. 4	50. 0	48. 6	47. 3	45. 9	44. 6	43. 3
400	71. 8	70. 1	68. 4	66. 7	65. 0	63. 4	61. 8	60. 3	58. 7	57. 2
300	91. 6	89. 4	87. 3	85. 2	83. 1	81. 1	79. 2	77. 3	75. 4	73. 6
200	117. 9	114. 7	111. 8	108. 9	106. 2	103. 6	101. 0	98. 6	96. 2	93. 9
100	162. 1	156. 0	150. 4	145. 3	140. 6	136. 2	132. 1	128. 2	124. 6	121. 1
0	------	309. 0	264. 8	238. 9	220. 6	206. 3	194. 7	184. 9	176. 3	168. 8

CODE TABLE 11.—*Saturation mixing ratios (g/kg) for various temperatures (t° C.) and pressures (P mb)*

t° C. \ P mb.	1,050	1,000	950	900	850	800	750	700	650	600	550	500	450	400
40	47. 14	49. 68	52. 52	55. 70	59. 29	63. 37	68. 06	73. 49	79. 87	87. 46	96. 64	------	------	------
35	35. 30	37. 17	39. 25	41. 57	44. 19	47. 16	50. 56	54. 49	59. 08	64. 51	71. 04	79. 05	89. 09	------
30	26. 27	27. 64	29. 16	30. 86	32. 77	34. 94	37. 41	40. 25	43. 56	47. 47	52. 15	57. 84	64. 94	74. 02
25	19. 39	20. 40	21. 51	22. 74	24. 13	25. 70	27. 49	29. 55	31. 94	34. 75	38. 10	42. 17	47. 21	53. 62
20	14. 20	14. 93	15. 73	16. 63	17. 64	18. 77	20. 06	21. 55	23. 27	25. 28	27. 68	30. 59	34. 17	38. 71
15	10. 29	10. 81	11. 39	12. 04	12. 76	13. 57	14. 50	15. 56	16. 79	18. 23	19. 94	22. 01	24. 55	27. 75
10	7. 37	7. 75	8. 16	8. 62	9. 13	9. 71	10. 37	11. 24	12. 00	13. 02	14. 23	15. 69	17. 48	19. 73
5	5. 22	5. 48	5. 77	6. 10	6. 46	6. 87	7. 33	7. 86	8. 47	9. 19	10. 04	10. 58	12. 31	13. 88
0	3. 64	3. 82	4. 03	4. 25	4. 50	4. 79	5. 11	5. 48	5. 90	6. 40	6. 99	7. 69	8. 56	9. 65
−5	2. 51	2. 64	2. 78	2. 93	3. 11	3. 30	3. 53	3. 78	4. 07	4. 41	4. 82	5. 30	5. 90	6. 64
−10	1. 71	1. 79	1. 89	1. 99	2. 11	2. 24	2. 39	2. 56	2. 76	2. 99	3. 27	3. 60	4. 00	4. 50
−15	1. 14	1. 20	1. 26	1. 33	1. 41	1. 50	1. 60	1. 71	1. 85	2. 00	2. 18	2. 40	2. 67	3. 00
−20	. 748	. 786	. 827	. 873	. 925	. 983	1. 05	1. 12	1. 21	1. 31	1. 43	1. 57	1. 75	1. 97
−25	. 480	. 504	. 531	. 561	. 594	. 631	. 673	. 721	. 776	. 841	. 918	1. 01	1. 12	1. 26
−30	. 303	. 318	. 335	. 353	. 374	. 397	. 424	. 454	. 489	. 530	. 578	. 636	. 707	. 795
−35	. 186	. 196	. 206	. 217	. 230	. 245	. 261	. 280	. 301	. 326	. 356	. 391	. 435	. 489
−40	. 112	. 118	. 124	. 131	. 139	. 147	. 157	. 168	. 181	. 196	. 214	. 236	. 262	. 295
−45	. 066	. 069	. 073	. 077	. 081	. 086	. 092	. 099	. 106	. 115	. 126	. 138	. 154	. 173

NOTE.—Saturation with respect to liquid water is assumed at temperatures below 0° C.

Code Table 12.—*Symbols D_1D_1, D_2D_2, D_3D_3—Direction of the shear-stability ratio vector*

Code figure	Direction in degrees from N. through E., S., W.	Code figure	Direction in degrees from N. through E., S., W.	Code figure	Direction in degrees from N. through E., S., W.	Code figure	Direction in degrees from N. through E., S., W.
00	Calm	10	95–105	19	186–194	28	275–285
01	6–14	11	106–114	20	195–205	29	286–294
02	15–25	12	115–125	21	206–214	30	295–305
03	26–34	13	126–134	22	215–225	31	306–314
04	35–45	14	135–145	23	226–234	32	315–325
05	46–54	15	146–154	24	235–245	33	326–334
06	55–65	16	155–165	25	246–254	34	335–345
07	66–74	17	166–174	26	255–265	35	346–354
08	75–85	18	175–185	27	266–274	36	355–5
09	86–94						

Code Table 13.—*Symbols S_1S_1, S_2S_2, S_3S_3—Magnitude of the shear-stability ratio vector*

Code figure	Magnitude in decameters per second	Code figure	Magnitude in decameters per second	Code figure	Magnitude in decameters per second	Code figure	Magnitude in decameters per second
00	0	15	15	40	40	80	80
01	1	16	16	42	42	84	84
02	2	17	17	44	44	89	89
03	3	18	18	46	46	90	100
04	4	19	19	48	48	91	110
05	5	20	20	50	50	92	120
06	6	22	22	52	52	93	130
07	7	24	24	54	54	94	140
08	8	26	26	56	56	95	150
09	9	28	28	58	58	96	160
10	10	30	30	60	60	98	180
11	11	32	32	64	64	99	200 or over
12	12	34	34	68	68		
13	13	36	36	72	72		
14	14	38	38	76	76		

CODE TABLE 14.—*Symbol N—Total amount of all clouds*

Code figure	Proportion of sky covered, in tenths	On map
0	Absolutely no clouds in the sky	 (clear
1	Less than one tenth	
2	One tenth	
3	Two or three tenths	
4	Four, five, or six tenths	
5	Seven or eight tenths	
6	Nine tenths	
7	More than nine tenths, but with openings	
8	Sky completely covered with clouds	
9	Sky obscured by fog, dust storm, or other phenomena	

NOTE.—A slant is used for symbol N when darkness prevents an observation of cloud data or when th type of cloud, ceiling, and direction are not known.

CODE TABLE 15.—*Symbol V—Horizontal visibility*

Code figure	Visibility	Candle power [1]	On ma
0	Objects not visible at 150 feet (50 yards)	0.13	0
1	Objects visible at 150 feet but not at ⅛ mile	.9	0
2	Objects visible at ⅛ mile but not at 5/16 mile	3.5	[illegible]
3	Objects visible at 5/16 mile but not at ⅝ mile	10	[illegible]
4	Objects visible at ⅝ mile but not at 1¼ miles	35	[illegible]
5	Objects visible at 1¼ miles but not at 2½ miles	100	1
6	Objects visible at 2½ miles but not at 6 miles	420	2
7	Objects visible at 6 miles but not at 12 miles	1,250	6
8	Objects visible at 12 miles but not at 30 miles	4,500	12
9	Objects visible at 30 miles, or more		30

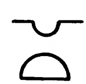
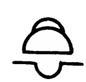
[1] When lights at these distances are used at night as visibility reference points they should be of the candle power listed above.

NOTE.—⅛ mile = 220 yards; 5/16 mile = 550 yards; ⅝ mile = 1,100 yards.

CODE TABLE 16.—*Symbol V—Visibility*

Code figure	Visibility	On map
0	Dense fog. (Objects not visible at 50 yards)	0
1	Thick fog. (Objects not visible at 200 yards)	0
2	Fog. (Objects not visible at 500 yards)	⅛
3	Moderate fog. (Objects not visible at ½ nautical mile)	¼
4	Thin fog. (Objects not visible at 1 nautical mile)	½
5	Poor visibility. (Objects not visible at 2 nautical miles)	1
6	Moderate visibility. (Objects not visible at 5 nautical miles)	2
7	Good visibility. (Objects not visible at 10 nautical miles)	6
8	Very good visibility. (Objects not visible at 30 nautical miles)	12
9	Excellent visibility. (Objects visible at more than 30 nautical miles)	30

CODE TABLE 17.—*Symbol C_L—Form of low cloud*

Code figure	Form of cloud	On map
0	No lower clouds	None.
1	Cumulus of fine weather	
2	Cumulus heavy and swelling, without anvil top	
3	Cumulonimbus	
4	Stratocumulus formed by the flattening of cumulus clouds	
5	Layer of stratus or stratocumulus	
6	Low broken-up clouds of bad weather	— — —
7	Cumulus of fine weather and stratocumulus	
8	Heavy or swelling cumulus, or cumulonimbus, and strato-cumulus	
9	Heavy or swelling cumulus (or cumulonimbus), and low, ragged clouds of bad weather	

CODE TABLE 18.—*Symbol C_M—Form of middle cloud*

Code figure	Form of cloud	On map
0	No middle clouds	None.
1	Typical altostratus, thin	
2	Typical altostratus, thick (or nimbostratus)	
3	Altocumulus or high stratocumulus sheet at one level only	
4	Altocumulus in small isolated patches; individual clouds often show signs of evaporation and are more or less lenticular in shape	
5	Altocumulus arranged in more or less parallel bands, or an ordered layer advancing over the sky	
6	Altocumulus formed by a spreading out of the tops of cumulus	
7	Altocumulus associated with altostratus or altostratus with a partially altocumulus character	
8	Altocumulus castellatus, or scattered cumuliform tufts	
9	Altocumulus in several sheets at different levels, generally associated with thick fibrous veils of cloud and a chaotic appearance of the sky	

CODE TABLE 19.—*Symbol C_H—Form of high cloud (cirrus cloud)*

Code figure	Form of cloud	On map
0	No upper clouds (no high clouds)	None.
1	Cirrus, delicate, not increasing, scattered and isolated masses	
2	Cirrus, delicate, not increasing, abundant but not forming a continuous layer.	
3	Cirrus of anvil clouds, usually dense	
4	Cirrus, increasing, generally in the form of hooks ending in a point or in a small tuft	
5	Cirrus (often in polar bands) or cirrostratus advancing over the sky but not more than 45° above the horizon	
6	Cirrus (often in polar bands) or cirrostratus advancing over the sky and more than 45° above the horizon	
7	Veil of cirrostratus covering the whole sky	
8	Cirrostratus not increasing, and not covering the whole sky	
9	Cirrocumulus predominating, associated with a small quantity of cirrus	

CODE TABLE 20.—*Symbol h—Lowest height above the ground at which total cloudiness present covers more than five-tenths of the sky* [1]

Code figure	Height	On map	Code figure	Height	On map
0	Zero to 149 feet	0	6	3,000 to 4,999 feet	30
1	150 to 299 feet	1	7	5,000 to 6,999 feet	50
2	300 to 599 feet	3	8	7,000 to 9,999 feet	70
3	600 to 999 feet	6	9	10,000 feet and above (or unlimited)[2]	u
4	1,000 to 1,999 feet	10			
5	2,000 to 2,999 feet	20			

[1] The definition for symbol "h" corresponds to the description of "ceiling" in circular N.
[2] The figure "9" is also sent for symbol "h" when total cloudiness is exactly five-tenths, or less.

CODE TABLE 21.—*Symbol DC—Direction from which cloud is moving*

Code figure	True directions	On map	Code figure	True directions	On map
0	Calm or variable	C	5	Southwest	↗
1	Northeast	↙	6	West	→
2	East	←	7	Northwest	↘
3	Southeast	↖	8	North	↓
4	South	↑	9	Unknown [1]	U

[1] It is extremely important that a *correct* direction of clouds be sent whenever possible.

CODE TABLE 22.—*Symbols DD—Direction of surface wind.*
Symbols D_xD_x—Direction of highest wind

Code figures	True directions	Code figures	True directions
00	Calm.	18	South-southwest.
02	North-northeast.	20	Southwest.
04	Northeast.	22	West-southwest.
06	East-northeast.	24	West.
08	East.	26	West-northwest.
10	East-southeast.	28	Northwest.
12	Southeast.	30	North-northwest.
14	South-southeast.	32	North.
16	South.		

NOTE 1.—Wind direction is direction *from which* wind is blowing. When wind recorders show direction to only 8 points, eye observation of direction is used.
NOTE 2.—In the ship code, when unusual squalliness or gustiness has occurred during the hour preceding the observation, the observer adds 33 to the number for the wind direction DD. When a squall or line squall has occurred in the hour preceding the observation, the observer adds 67 to the wind direction given in the table.

CODE TABLE 23a.—*Symbol F—Wind force in Beaufort scale.*

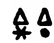
Code figure	Explanatory title	Miles per hour (statute)	Terms used in W. B. forecasts	Beaufort number	On map, barbs used
0	Calm	Less than 1	Light	0	0
1	Light air	1–3		1	½
2	Slight breeze	4–7		2	1
3	Gentle breeze	8–12	Gentle	3	1½
4	Moderate breeze	13–18	Moderate	4	2
5	Fresh breeze	19–24	Fresh	5	2½
6	Strong breeze	25–31	Strong	6	3
7	High wind	32–38		7	3½
8	Gale	39–46	Gale	8	4
9	Strong gale	47–54		9	4½
9	Whole gale [1]	55–63	Whole gale	10	5
9	Storm [1]	64–75		11	5½
9	Hurricane [1]	Above 75	Hurricane	12	6

[1] Code Symbol F as "9" and add word at end of message as follows: GALE for Beaufort force 10; STORM for Beaufort force 11; HURRICANE for Beaufort force 12.

CODE TABLE 23b.—*Wind velocity equivalents*

Descriptive word	Velocity (miles per hour)	Specifications for estimating velocities
Calm	Less than 1	Smoke rises vertically.
Light	1 to 3	Direction of wind shown by smoke drift, but not by wind vanes.
	4 to 7	Wind felt on face; leaves rustle; ordinary vane moved by wind.
Gentle	8 to 12	Leaves and small twigs in constant motion; wind extends light flag.
Moderate	13 to 18	Raises dust and loose paper; small branches are moved.
Fresh	19 to 24	Small trees in leaf begin to sway; crested wavelets form on inland waters.
Strong	25 to 31	Large branches in motion; whistling heard in telegraph wires; umbrellas used with difficulty.
	32 to 38	Whole trees in motion; inconvenience felt in walking against the wind.
Gale	39 to 46	Breaks twigs off trees; generally impedes progress.
	47 to 54	Slight structural damage occurs (chimney pots and slate removed).
	55 to 63	Trees uprooted; considerable structural damage occurs.
Whole gale	64 to 75	Rarely experienced; accompanied by widespread damage.
Hurricane	Above 75	

CODE TABLE 24.—*Symbol R_c—Character of precipitation or thunderstorm*

Code figure	Description	On map
0	Character of precipitation unknown	U
1	Sleet or ice	△
2	Snow and rain mixed	
3	Intermittent (rain or snow)	•✱ (either or both)
4	Showers (of rain or snow)	 (either or both)
5	Drizzle	, ,
6	Rain (continuous)	••
7	Snow (continuous)	✱✱
8	Thunderstorm with no precipitation at station [1]	
9	Thunderstorm with precipitation at station [1]	

[1] Underline in red when entry is made on map.

NOTE.—The character of the last occurrence is coded, except that when a thunderstorm has occurred and has not been reported in a previous regular report the code figures 8 or 9 are always used in preference to a lower figure for R_c.

CODE TABLE 25.—*Symbol R_t—Time thunderstorm began, or time precipitation began or ended*

Code figure	Hours preceding time of the observation	On map
0	Unknown (but less than 6 hours ago)	u
1	Less than 1 hour ago	(1)
2	From 1 to 2 hours ago	(1)
3	From 2 to 3 hours ago	(1)
4	From 3 to 4 hours ago	(1)
5	From 4 to 5 hours ago	(1)
6	From 5 to 6 hours ago	(1)
7	From 6 to 12 hours ago	(1)
8	From 12 to 18 hours ago	(2)
9	More than 18 hours ago	(2)

[1] On map: Add 30 minutes to the map time; subtract code figure.
[2] On map: Subtract 30 minutes from map time; subtract minimum hours for each code figure; e. g., for "8", subtract "12"; for "9", subtract "18".

NOTE.—When R_c is 8 or 9, R_t is the time thunderstorm began. When R_c is 0, 1, 2, 3, 4, 5, 6 or 7, R_t is the time precipitation began (if precipitation is falling at time of observation), or is the time precipitation ended (if precipitation is not falling at time of observation).

CODE TABLE 26.—*Symbol R_s—Depth of snow on ground*

Code figure	Depth of snow	On map [1]	On map [2]
0	Trace to 0.9 inches	0. 9	1
1	1.0 to 2.9 inches	2. 9	3
2	3.0 to 4.9 inches	4. 9	5
3	5.0 to 6.9 inches	6. 9	7
4	7.0 to 8.9 inches	8. 9	9
5	9.0 to 14.9 inches	14. 9	15
6	15.0 to 20.9 inches	20. 9	21
7	21.0 to 26.9 inches	26. 9	27
8	27.0 to 32.9 inches	32. 9	33
9	33 inches or more	33	33+

[1] Snow map. [2] When entered on synoptic map, the highest figure will be placed beneath either C_L or D_xD_x and F_xF_x.

NOTE.—When there is absolutely no snow on the ground at station no figure for symbol R_s is used.

ODE TABLE 27.—*Symbol a—Characteristic of barometric tendency during 3-hour period ending at time of observation; symbol a_1—Characteristic of barometric tendency during 3-hour period ending 3 hours ago*

Designation	Schematic representation	Characteristic of barometric tendency	
0		Rising, then falling	Barometer now higher than or same as 3 hours ago.
1		Rising, then steady; or rising, then rising more slowly.	
2		Unsteady	
3		Steady or rising	
4		Falling or steady, then rising; or rising, then rising more quickly.	
5		Falling, then rising	Barometer now lower than 3 hours ago.
6		Falling, then steady; or falling, then falling more slowly.	
7		Unsteady	
8		Falling	
9		Rising or steady, then falling; or falling, then falling more quickly.	

NOTE 1.—Characteristics 2 and 7 are to be used only for those 3-hour segments of the trace which contain at least two crests or two troughs. These crests or troughs must be so pronounced that points on them lie at a greater distance from the mean slope of the trace than the distance representing 0.02-inch on the barograph sheet. Crests of a trace are here defined as follows: Points at which pressure ceases to rise and begins to fall; points at which pressure starts falling more rapidly, provided that a point at which pressure begins to fall more slowly exists between two of these points; or points at which pressure begins to rise more slowly, provided that a point at which pressure begins to rise more rapidly exists between two of these points. Similar definitions also hold for the troughs of a trace. The "mean slope" of a trace segment is defined to be a straight line drawn in such a way that it coincides as nearly as possible with the portion of the trace in question.

NOTE 2.—No attention should be paid to variations from the mean slope of the trace of less than 0.01-inch distance on the chart. Furthermore, no attention will be paid to variations in slope of less than 22½° in the microbarograph trace segment, or less than 15° in the barograph trace segment.

NOTE 3.—If the 3-hour trace segment does not have enough sufficiently pronounced crests or troughs to be classified as having a 2 or 7 characteristic, and there is doubt as to which of the other characteristics should be used, the characteristic chosen should, in all cases, be that which is compatible with the net 3-hour change and with the latter part of the trace.

CODE TABLE 28.—*Symbol A—Barometric tendency*

Code figure	Barometric tendency	On map
0	Barometer steady. (Has not fallen or risen more than 0.01 inch, or ½ millibar, in last 3 hours)	╱╲5
1	Barometer rising slowly. (Has risen 0.03 to 0.04 inch or 1 to 1½ millibars in last 3 hours)	╱10
2	Barometer rising. (Has risen 0.06 to 0.10 inch or 2 to 3½ millibars, in last 3 hours)	╱20
3	Barometer rising quickly. (Has risen 0.12 to 0.18 inch or 4 to 6 millibars in last 3 hours)	╱40
4	Barometer rising very rapidly. (Has risen more than 0.18 inch or 6 millibars in last 3 hours)	╱60
5	Barometer falling slowly. (Has fallen 0.03 to 0.04 inch or 1 to 1½ millibars in last 3 hours)	╲10
6	Barometer falling. (Has fallen 0.06 to 0.10 inch, or 2 to 3½ millibars in last 3 hours)	╲20
7	Barometer falling quickly. (Has fallen 0.12 to 0.18 inch or 4 to 6 millibars in last 3 hours)	╲40
8	Barometer falling very rapidly. (Has fallen more than 0.18 inch or 6 millibars in last 3 hours)	╲60

Code Table 29.—*Symbols pp—Amount of barometric tendency*

[Net change of the barometer in the last 3 hours]

Code figure [1]	Inches [2]	Code figure [1]	Inches [2]	Code figure [1]	Inches [2]	Code figure [1]	Inches [2]
00	0. 000	25	0. 150	51	0. 300	76	0. 450
01	. 005	26	. 155	52	. 305	77	. 455
02	. 010	27	. 160	52	. 310	78	. 460
03	. 015	28	. 165	53	. 315	79	. 465
03	. 020	29	. 170	54	. 320	80	. 470
04	. 025	30	. 175	55	. 325	80	. 475
05	. 030	30	. 180	56	. 330	81	. 480
06	. 035	31	. 185	57	. 335	82	. 485
07	. 040	32	. 190	58	. 340	83	. 490
08	. 045	33	. 195	58	. 345	84	. 495
08	. 050	34	. 200	59	. 350	85	. 500
09	. 055	35	. 205	60	. 355	86	. 505
10	. 060	36	. 210	61	. 360	86	. 510
11	. 065	36	. 215	62	. 365	87	. 515
12	. 070	37	. 220	63	. 370	88	. 520
13	. 075	38	. 225	63	. 375	89	. 525
14	. 080	39	. 230	64	. 380	90	. 530
14	. 085	40	. 235	65	. 385	91	. 535
15	. 090	41	. 240	66	. 390	91	. 540
16	. 095	41	. 245	67	. 395	92	. 545
17	. 100	42	. 250	68	. 400	93	. 550
18	. 105	43	. 255	69	. 405	94	. 555
19	. 110	44	. 260	69	. 410	95	. 560
19	. 115	45	. 265	70	. 415	96	. 565
20	. 120	46	. 270	71	. 420	97	. 570
21	. 125	47	. 275	72	. 425	97	. 575
22	. 130	47	. 280	73	. 430	98	. 580
23	. 135	48	. 285	74	. 435	99	. 585
24	. 140	49	. 290	75	. 440	[3] 00	. 590
25	. 145	50	. 295	75	. 445	[3] 01	. 595

[1] The code figure represents the number of fifths of millibars of pressure change.
[2] Multiply code figure by 2 for figure on map.
[3] Add word "TWENTY" at end of message.

CODE TABLE 30.—*Symbol PPP—Atmospheric pressure reduced to sea level*

[Sent in units and tenths of millibars, initial 9 or 10 omitted. One inch=33.86395 millibars; one millibar=0.02952993 inch]

Inches	Millibars	Inches	Millibars	Inches	Millibars	Inches	Millibars
27.00	914.3	27.44	929.2	27.88	944.1	28.32	959.0
27.01	914.7	27.45	929.6	27.89	944.5	28.33	959.4
27.02	915.0	27.46	929.9	27.90	944.8	28.34	959.7
27.03	915.3	27.47	930.2	27.91	945.1	28.35	960.0
27.04	915.7	27.48	930.6	27.92	945.5	28.36	960.4
27.05	916.0	27.49	930.9	27.93	945.8	28.37	960.7
27.06	916.4	27.50	931.3	27.94	946.2	28.38	961.1
27.07	916.7	27.51	931.6	27.95	946.5	28.39	961.4
27.08	917.0	27.52	931.9	27.96	946.8	28.40	961.7
27.09	917.4	27.53	932.3	27.97	947.2	28.41	962.1
27.10	917.7	27.54	932.6	27.98	947.5	28.42	962.4
27.11	918.1	27.55	933.0	27.99	947.9	28.43	962.8
27.12	918.4	27.56	933.3	28.00	948.2	28.44	963.1
27.13	918.7	27.57	933.6	28.01	948.5	28.45	963.4
27.14	919.1	27.58	934.0	28.02	948.9	28.46	963.8
27.15	919.4	27.59	934.3	28.03	949.2	28.47	964.1
27.16	919.7	27.60	934.6	28.04	949.5	28.48	964.4
27.17	920.1	27.61	935.0	28.05	949.9	28.49	964.8
27.18	920.4	27.62	935.3	28.06	950.2	28.50	965.1
27.19	920.8	27.63	935.7	28.07	950.6	28.51	965.5
27.20	921.1	27.64	936.0	28.08	950.9	28.52	965.8
27.21	921.4	27.65	936.3	28.09	951.2	28.53	966.1
27.22	921.8	27.66	936.7	28.10	951.6	28.54	966.5
27.23	922.1	27.67	937.0	28.11	951.9	28.55	966.8
27.24	922.5	27.68	937.4	28.12	952.3	28.56	967.2
27.25	922.8	27.69	937.7	28.13	952.6	28.57	967.5
27.26	923.1	27.70	938.0	28.14	952.9	28.58	967.8
27.27	923.5	27.71	938.4	28.15	953.3	28.59	968.2
27.28	923.8	27.72	938.7	28.16	953.6	28.60	968.5
27.29	924.1	27.73	939.0	28.17	953.9	28.61	968.8
27.30	924.5	27.74	939.4	28.18	954.3	28.62	969.2
27.31	924.8	27.75	939.7	28.19	954.6	28.63	969.5
27.32	925.2	27.76	940.1	28.20	955.0	28.64	969.9
27.33	925.5	27.77	940.4	28.21	955.3	28.65	970.2
27.34	925.8	27.78	940.7	28.22	955.6	28.66	970.5
27.35	926.2	27.79	941.1	28.23	956.0	28.67	970.9
27.36	926.5	27.80	941.4	28.24	956.3	28.68	971.2
27.37	926.9	27.81	941.8	28.25	956.7	28.69	971.6
27.38	927.2	27.82	942.1	28.26	957.0	28.70	971.9
27.39	927.5	27.83	942.4	28.27	957.3	28.71	972.2
27.40	927.9	27.84	942.8	28.28	957.7	28.72	972.6
27.41	928.2	27.85	943.1	28.29	958.0	28.73	972.9
27.42	928.5	27.86	943.4	28.30	958.3	28.74	973.2
27.43	928.9	27.87	943.8	28.31	958.7	28.75	973.6

CODE TABLE 30.—*Symbol PPP—Atmospheric pressure reduced to sea level*—Con.

Inches	Millibars	Inches	Millibars	Inches	Millibars	Inches	Millibars
28. 76	973. 9	29. 22	989. 5	29. 68	1, 005. 1	30. 14	1, 020. 7
28. 77	974. 3	29. 23	989. 8	29. 69	1, 005. 4	30. 15	1, 021. 0
28. 78	974. 6	29. 24	990. 2	29. 70	1, 005. 8	30. 16	1, 021. 3
28. 79	974. 9	29. 25	990. 5	29. 71	1, 006. 1	30. 17	1, 021. 7
28. 80	975. 3	29. 26	990. 9	29. 72	1, 006. 4	30. 18	1, 022. 0
28. 81	975. 6	29. 27	991. 2	29. 73	1, 006. 8	30. 19	1, 022. 4
28. 82	976. 0	29. 28	991. 5	29. 74	1, 007. 1	30. 20	1, 022. 7
28. 83	976. 3	29. 29	991. 9	29. 75	1, 007. 5	30. 21	1, 023. 0
28. 84	976. 6	29. 30	992. 2	29. 76	1, 007. 8	30. 22	1, 023. 4
28. 85	977. 0	29. 31	992. 6	29. 77	1, 008. 1	30. 23	1, 023. 7
28. 86	977. 3	29. 32	992. 9	29. 78	1, 008. 5	30. 24	1, 024. 0
28. 87	977. 7	29. 33	993. 2	29. 79	1, 008. 8	30. 25	1, 024. 4
28. 88	978. 0	29. 34	993. 6	29. 80	1, 009. 1	30. 26	1, 024. 7
28. 89	978. 3	29. 35	993. 9	29. 81	1, 009. 5	30. 27	1, 025. 1
28. 90	978. 7	29. 36	994. 2	29. 82	1, 009. 8	30. 28	1, 025. 4
28. 91	979. 0	29. 37	994. 6	29. 83	1, 010. 2	30. 29	1, 025. 7
28. 92	979. 3	29. 38	994. 9	29. 84	1, 010. 5	30. 30	1, 026. 1
28. 93	979. 7	29. 39	995. 3	29. 85	1, 010. 8	30. 31	1, 026. 4
28. 94	980. 0	29. 40	995. 6	29. 86	1, 011. 2	30. 32	1, 026. 8
28. 95	980. 4	29. 41	995. 9	29. 87	1, 011. 5	30. 33	1, 027. 1
28. 96	980. 7	29 42	996. 3	29. 88	1, 011. 9	30. 34	1, 027. 4
28. 97	981. 0	29. 43	996. 6	29. 89	1, 012. 2	30. 35	1, 027. 8
28. 98	981. 4	29. 44	997. 0	29. 90	1, 012. 5	30. 36	1, 028. 1
28. 99	981. 7	29. 45	997. 3	29. 91	1, 012. 9	30. 37	1, 028. 4
29. 00	982. 1	29. 46	997. 6	29. 92	1, 013. 2	30. 38	1, 028. 8
29. 01	982. 4	29. 47	998. 0	29. 93	1, 013. 5	30. 39	1, 029. 1
29. 02	982. 7	29. 48	998. 3	29. 94	1, 013. 9	30. 40	1, 029. 5
29. 03	983. 1	29. 49	998. 6	29. 95	1, 014. 2	30. 41	1, 029. 8
29. 04	983. 4	29. 50	999. 0	29. 96	1, 014. 6	30. 42	1, 030. 1
29. 05	983. 7	29. 51	999. 3	29. 97	1, 014. 9	30. 43	1, 030. 5
29. 06	984. 1	29. 52	999. 7	29. 98	1, 015. 2	30. 44	1, 030. 8
29. 07	984. 4	29. 53	1, 000. 0	29. 99	1, 015. 6	30. 45	1, 031. 2
29. 08	984. 8	29. 54	1, 000. 3	30. 00	1, 015. 9	30. 46	1, 031. 5
29. 09	985. 1	29. 55	1, 000. 7	30. 01	1, 016. 3	30. 47	1, 031. 8
29. 10	985. 4	29. 56	1, 001. 0	30. 02	1, 016. 6	30. 48	1, 032. 2
29. 11	985. 8	29. 57	1, 001. 4	30. 03	1, 016. 9	30. 49	1, 032. 5
29. 12	986. 1	29. 58	1, 001. 7	30. 04	1, 017. 3	30. 50	1, 032. 9
29. 13	986. 5	29. 59	1, 002. 0	30. 05	1, 017. 6	30. 51	1, 033. 2
29. 14	986. 8	29. 60	1, 002. 4	30. 06	1, 018. 0	30. 52	1, 033. 5
29. 15	987. 1	29. 61	1, 002. 7	30. 07	1, 018. 3	30. 53	1, 033. 9
29. 16	987. 5	29. 62	1, 003. 1	30. 08	1, 018. 6	30. 54	1, 034. 2
29. 17	987. 8	29. 63	1, 003. 4	30. 09	1, 019. 0	30. 55	1, 034. 5
29. 18	988. 2	29. 64	1, 003. 7	30. 10	1, 019. 3	30. 56	1, 034. 9
29. 19	988. 5	29. 65	1, 004. 1	30. 11	1, 019. 6	30. 57	1, 035. 2
29. 20	988. 8	29. 66	1, 004. 4	30. 12	1, 020. 0	30. 58	1, 035. 6
29. 21	989. 2	29. 67	1, 004. 7	30. 13	1, 020. 3	30. 59	1, 035. 9

CODE TABLE 30.—*Symbol PPP—Atmospheric pressure reduced to sea level*—Con.

Inches	Millibars	Inches	Millibars	Inches	Millibars	Inches	Millibars
30. 60	1, 036. 2	30. 95	1, 048. 1	31. 30	1, 059. 9	31. 65	1, 071. 8
30. 61	1, 036. 6	30. 96	1, 048. 4	31. 31	1, 060. 3	31. 66	1, 072. 1
30. 62	1, 036. 9	30. 97	1, 048. 8	31. 32	1, 060. 6	31. 67	1, 072. 5
30. 63	1, 037. 3	30. 98	1, 049. 1	31. 33	1, 061. 0	31. 68	1, 072. 8
30. 64	1, 037. 6	30. 99	1, 049. 5	31. 34	1, 061. 3	31. 69	1, 073. 1
30. 65	1, 037. 9	31. 00	1, 049. 8	31. 35	1, 061. 6	31. 70	1, 073. 5
30. 66	1, 038. 3	31. 01	1, 050. 1	31. 36	1, 062. 0	31. 71	1, 073. 8
30. 67	1, 038. 6	31. 02	1, 050. 5	31. 37	1, 062. 3	31. 72	1, 074. 2
30. 68	1, 038. 9	31. 03	1, 050. 8	31. 38	1, 062. 7	31. 73	1, 074. 5
30. 69	1, 039. 3	31. 04	1, 051. 1	31. 39	1, 063. 0	31. 74	1, 074. 8
30. 70	1, 039. 6	31. 05	1, 051. 5	31. 40	1, 063. 3	31. 75	1, 075. 2
30. 71	1, 040. 0	31. 06	1, 051. 8	31. 41	1, 063. 7	31. 76	1, 075. 5
30. 72	1, 040. 3	31. 07	1, 052. 2	31. 42	1, 064. 0	31. 77	1, 075. 9
30. 73	1, 040. 6	31. 08	1, 052. 5	31. 43	1, 064. 3	31. 78	1, 076. 2
30. 74	1, 041. 0	31. 09	1, 052. 8	31. 44	1, 064. 7	31. 79	1, 076. 5
30. 75	1, 041. 3	31. 10	1, 053. 2	31. 45	1, 065. 0	31. 80	1, 076. 9
30. 76	1, 041. 7	31. 11	1, 053. 5	31. 46	1, 065. 4	31. 81	1, 077. 2
30. 77	1, 042. 0	31. 12	1, 053. 8	31. 47	1, 065. 7	31. 82	1, 077. 6
30. 78	1, 042. 3	31. 13	1, 054. 2	31. 48	1, 066. 0	31. 83	1, 077. 9
30. 79	1, 042. 7	31. 14	1, 054. 5	31. 49	1, 066. 4	31. 84	1, 078. 2
30. 80	1, 043. 0	31. 15	1, 054. 9	31. 50	1, 066. 7	31. 85	1, 078. 6
30. 81	1, 043. 3	31. 16	1, 055. 2	31. 51	1, 067. 1	31. 86	1, 078. 9
30. 82	1, 043. 7	31. 17	1, 055. 5	31. 52	1, 067. 4	31. 87	1, 079. 2
30. 83	1, 044. 0	31. 18	1, 055. 9	31. 53	1, 067. 7	31. 88	1, 079. 6
30. 84	1, 044. 4	31. 19	1, 056. 2	31. 54	1, 068. 1	31. 89	1, 079. 9
30. 85	1, 044. 7	31. 20	1, 056. 6	31. 55	1, 068. 4	31. 90	1, 080. 3
30. 86	1, 045. 0	31. 21	1, 056. 9	31. 56	1, 068. 7	31. 91	1, 080. 6
30. 87	1, 045. 4	31. 22	1, 057. 2	31. 57	1, 069. 1	31. 92	1, 080. 9
30. 88	1, 045. 7	31. 23	1, 057. 6	31. 58	1, 069. 4	31. 93	1, 081. 3
30. 89	1, 046. 1	31. 24	1, 057. 9	31. 59	1, 069. 8	31. 94	1, 081. 6
30. 90	1, 046. 4	31. 25	1, 058. 2	31. 60	1, 070. 1	31. 95	1, 082. 0
30. 91	1, 046. 7	31. 26	1, 058. 6	31. 61	1, 070. 4	31. 96	1, 082. 3
30. 92	1, 047. 1	31. 27	1, 058. 9	31. 62	1, 070. 8	31. 97	1, 082. 6
30. 93	1, 047. 4	31. 28	1, 059. 3	31. 63	1, 071. 1	31. 98	1, 083. 0
30. 94	1, 047. 8	31. 29	1, 059. 6	31. 64	1, 071. 5	31. 99	1, 083. 3

CODE TABLE 31.—*Symbol $P_mP_mP_m$—Atmospheric pressure reduced to 5,000-foot plane*

Sent in units and tenths of millibars initial figure omitted (one inch=33.86395 millibars; one millibar=0.02952993 inch)]

Inches	Millibars	Inches	Millibars	Inches	Millibars	Inches	Millibars
23. 00	778. 9	23. 43	793. 4	23. 86	808. 0	24. 29	822. 6
23. 01	779. 2	23. 44	793. 8	23. 87	808. 3	24. 30	822. 9
23. 02	779. 5	23. 45	794. 1	23. 88	808. 7	24. 31	823. 2
23. 03	779. 9	23. 46	794. 4	23. 89	809. 0	24. 32	823. 6
23. 04	780. 2	23. 47	794. 8	23. 90	809. 3	24. 33	823. 9
23. 05	780. 6	23. 48	795. 1	23. 91	809. 7	24. 34	824. 2
23. 06	780. 9	23. 49	795. 5	23. 92	810. 0	24. 35	824. 6
23. 07	781. 2	23. 50	795. 8	23. 93	810. 4	24. 36	824. 9
23. 08	781. 6	23. 51	796. 1	23. 94	810. 7	24. 37	825. 3
23. 09	781. 9	23. 52	796. 5	23. 95	811. 0	24. 38	825. 6
23. 10	782. 3	23. 53	796. 8	23. 96	811. 4	24. 39	825. 9
23. 11	782. 6	23. 54	797. 2	23. 97	811. 7	24. 40	826. 3
23. 12	782. 9	23. 55	797. 5	23. 98	812. 1	24. 41	826. 6
23. 13	783. 3	23. 56	797. 8	23. 99	812. 4	24. 42	827. 0
23. 14	783. 6	23. 57	798. 2	24. 00	812. 7	24. 43	827. 3
23. 15	784. 0	23. 58	798. 5	24. 01	813. 1	24. 44	827. 6
23. 16	784. 3	23. 59	798. 9	24. 02	813. 4	24. 45	828. 0
23. 17	784. 6	23. 60	799. 2	24. 03	813. 8	24. 46	828. 3
23. 18	785. 0	23. 61	799. 5	24. 04	814. 1	24. 47	828. 7
23. 19	785. 3	23. 62	799. 9	24. 05	814. 4	24. 48	829. 0
23. 20	785. 6	23. 63	800. 2	24. 06	814. 8	24. 49	829. 3
23. 21	786. 0	23. 64	800. 5	24. 07	815. 1	24. 50	829. 7
23. 22	786. 3	23. 65	800. 9	24. 08	815. 4	24. 51	830. 0
23. 23	786. 7	23. 66	801. 2	24. 09	815. 8	24. 52	830. 3
23. 24	787. 0	23. 67	801. 6	24. 10	816. 1	24. 53	830. 7
23. 25	787. 3	23. 68	801. 9	24. 11	816. 5	24. 54	831. 0
23. 26	787. 7	23. 69	802. 2	24. 12	816. 8	24. 55	831. 4
23. 27	788. 0	23. 70	802. 6	24. 13	817. 1	24. 56	831. 7
23. 28	788. 4	23. 71	802. 9	24. 14	817. 5	24. 57	832. 0
23. 29	788. 7	23. 72	803. 3	24. 15	817. 8	24. 58	832. 4
23. 30	789. 0	23. 73	803. 6	24. 16	818. 2	24. 59	832. 7
23. 31	789. 4	23. 74	803. 9	24. 17	818. 5	24. 60	833. 1
23. 32	789. 7	23. 75	804. 3	24. 18	818. 8	24. 61	833. 4
23. 33	790. 0	23. 76	804. 6	24. 19	819. 2	24. 62	833. 7
23. 34	790. 4	23. 77	804. 9	24. 20	819. 5	24. 63	834. 1
23. 35	790. 7	23. 78	805. 3	24. 21	819. 8	24. 64	834. 4
23. 36	791. 1	23. 79	805. 6	24. 22	820. 2	24. 65	834. 7
23. 37	791. 4	23. 80	806. 0	24. 23	820. 5	24. 66	835. 1
23. 38	791. 7	23. 81	806. 3	24. 24	820. 9	24. 67	835. 4
23. 39	792. 1	23. 82	806. 6	24. 25	821. 2	24. 68	835. 8
23. 40	792. 4	23. 83	807. 0	24. 26	821. 5	24. 69	836. 1
23. 41	792. 8	23. 84	807. 3	24. 27	821. 9	24. 70	836. 4
23. 42	793. 1	23. 85	807. 7	24. 28	822. 2	24. 71	836. 8

CODE TABLE 31.—*Symbol $P_mP_mP_m$—Atmospheric pressure reduced to 5,000-foot plane*—Continued

Inches	Millibars	Inches	Millibars	Inches	Millibars	Inches	Millibars
24. 72	837. 1	25. 16	852. 0	25. 60	866. 9	26. 04	881. 8
24. 73	837. 5	25. 17	852. 4	25. 61	867. 3	26. 05	882. 2
24. 74	837. 8	25. 18	852. 7	25. 62	867. 6	26. 06	882. 5
24. 75	838. 1	25. 19	853. 0	25. 63	867. 9	26. 07	882. 8
24. 76	838. 5	25. 20	853. 4	25. 64	868. 3	36. 08	883. 2
24. 77	838. 8	25. 21	853. 7	25. 65	868. 6	26. 09	883. 5
24. 78	839. 1	25. 22	854. 0	25. 66	868. 9	26. 10	883. 8
24. 79	839. 5	25. 23	854. 4	25. 67	869. 3	26. 11	884. 2
24. 80	839. 8	25. 24	854. 7	25. 68	869. 6	26. 12	884. 5
24. 81	840. 2	25. 25	855. 1	25. 69	870. 0	26. 13	884. 9
24. 82	840. 5	25. 26	855. 4	25. 70	870. 3	26. 14	885. 2
24. 83	840. 8	25. 27	855. 7	25. 71	870. 6	26. 15	885. 5
24. 84	841. 2	25. 28	856. 1	25. 72	871. 0	26. 16	885. 9
24. 85	841. 5	25. 29	856. 4	25. 73	871. 3	26. 17	886. 2
24. 86	841. 9	25. 30	856. 8	25. 74	871. 7	26. 18	886. 6
24. 87	842. 2	25. 31	857. 1	25. 75	872. 0	26. 19	886. 9
24. 88	842. 5	25. 32	857. 4	25. 76	872. 3	26. 20	887. 2
24. 89	842. 9	25. 33	857. 8	25. 77	872. 7	26. 21	887. 6
24. 90	843. 2	25. 34	858. 1	25. 78	873. 0	26. 22	887. 9
24. 91	843. 6	25. 35	858. 5	25. 79	873. 4	26. 23	888. 3
24. 92	843. 9	25. 36	858. 8	25. 80	873. 7	26. 24	888. 6
24. 93	844. 2	25. 37	359. 1	25. 81	874. 0	26. 25	888. 9
24. 94	844. 6	25. 38	859. 5	25. 82	874. 4	26. 26	889. 3
24. 95	844. 9	25. 39	859. 8	25. 83	874. 7	26. 27	889. 6
24. 96	845. 2	25. 40	860. 1	25. 84	875. 0	26. 28	889. 9
24. 97	845. 6	25. 41	860. 5	25. 85	875. 4	26. 29	890. 3
24. 98	845. 9	25. 42	860. 8	25. 86	875. 7	26. 30	890. 6
24. 99	846. 3	25. 43	861. 2	25. 87	876. 1	26. 31	891. 0
25. 00	846. 6	25. 44	861. 5	25. 88	876. 4	26. 32	891. 3
25. 01	846. 9	25. 45	861. 8	25. 89	876. 7	26. 33	891. 6
25. 02	847. 3	25. 46	862. 2	25. 90	877. 1	26. 34	892. 0
25. 03	847. 6	25. 47	862. 5	25. 91	877. 4	26. 35	892. 3
25. 04	848. 0	25. 48	862. 9	25. 92	877. 8	26. 36	892. 7
25. 05	848. 3	25. 49	863. 2	25. 93	878. 1	26. 37	893. 0
25. 06	848. 6	25. 50	863. 5	25. 94	878. 4	26. 38	893. 3
25. 07	849. 0	25. 51	863. 9	25. 95	878. 8	26. 39	893. 7
25. 08	849. 3	25. 52	864. 2	25. 96	879. 1	26. 40	894. 0
25. 09	849. 6	25. 53	864. 5	25. 97	879. 4	26. 41	894. 3
25. 10	850. 0	25. 54	864. 9	25. 98	879. 8	26. 42	894. 7
25. 11	850. 3	25. 55	865. 2	25. 99	880. 1	26. 43	895. 0
25. 12	850. 7	25. 56	865. 6	26. 00	880. 5	26. 44	895. 4
25. 13	851. 0	25. 57	865. 9	26. 01	880. 8	26. 45	895. 7
25. 14	851. 3	25. 58	866. 2	26. 02	881. 1	26. 46	896. 0
25. 15	851. 7	25. 59	866. 6	26. 03	881. 5	26. 47	896. 4

CODE TABLE 31.—*Symbol $P_mP_mP_m$—Atmospheric pressure reduced to 5,000-foot plane*—Continued

Inches	Millibars	Inches	Millibars	Inches	Millibars	Inches	Millibars
26. 48	896. 7	26. 61	901. 1	26. 74	905. 5	26. 87	909. 9
26. 49	897. 1	26. 62	901. 5	26. 75	905. 9	26. 88	910. 3
26. 50	897. 4	26. 63	901. 8	26. 76	906. 2	26. 89	910. 6
26. 51	897. 7	26. 64	902. 1	26. 77	906. 5	26. 90	910. 9
26. 52	898. 1	26. 65	902. 5	26. 78	906. 9	26. 91	911. 3
26. 53	898. 4	26. 66	902. 8	26. 79	907. 2	26. 92	911. 6
26. 54	898. 7	26. 67	903. 2	26. 80	907. 6	26. 93	912. 0
26. 55	899. 1	26. 68	903. 5	26. 81	907. 9	26. 94	912. 3
26. 56	899. 4	26. 69	903. 8	26. 82	908. 2	26. 95	912. 6
26. 57	899. 8	26. 70	904. 2	26. 83	908. 6	26. 96	913. 0
26. 58	900. 1	26. 71	904. 5	26. 84	908. 9	26. 97	913. 3
26. 59	900. 4	26. 72	904. 8	26. 85	909. 2	26. 98	913. 6
26. 60	900. 8	26. 73	905. 2	26. 86	909. 6	26. 99	914. 0

CODE TABLE 32.—*Symbols PP—Corrected barometer reading*

Code figure	Inches	Millibars	Code figure	Inches	Millibars	Code figure	Inches	Millibars
25	27. 32	925	70	28. 64	970	15	29. 97	1, 015
26	27. 34	926	71	28. 67	971	16	30. 00	1, 016
27	27. 37	927	72	28. 70	972	17	30. 03	1, 017
28	27. 40	928	73	28. 73	973	18	30. 06	1, 018
29	27. 43	929	74	28. 76	974	19	30. 09	1, 019
30	27. 46	930	75	28. 79	975	20	30. 12	1, 020
31	27. 49	931	76	28. 82	976	21	30. 15	1, 021
32	27. 52	932	77	28. 85	977	22	30. 18	1, 022
33	27. 55	933	78	28. 88	978	23	30. 21	1, 023
34	27. 58	934	79	28. 91	979	24	30. 24	1, 024
35	27. 61	935	80	28. 94	980	25	30. 27	1, 025
36	27. 64	936	81	28. 97	981	26	30. 30	1, 026
37	27. 67	937	82	29. 00	982	27	30. 33	1, 027
38	27. 70	938	83	29. 03	983	28	30. 36	1, 028
39	27. 73	939	84	29. 06	984	29	30. 39	1, 029
40	27. 76	940	85	29. 09	985	30	30. 42	1, 030
41	27. 79	941	86	29. 12	986	31	30. 45	1, 031
42	27. 82	942	87	29. 15	987	32	30. 47	1, 032
43	27. 85	943	88	29. 18	988	33	30. 50	1, 033
44	27. 88	944	89	29. 21	989	34	30. 53	1, 034
45	27. 91	945	90	29. 23	990	35	30. 56	1, 035
46	27. 94	946	91	29. 26	991	36	30. 59	1, 036
47	27. 96	947	92	29. 29	992	37	30. 62	1, 037
48	27. 99	948	93	29. 32	993	38	30. 65	1, 038
49	28. 02	949	94	29. 35	994	39	30. 68	1, 039
50	28. 05	950	95	29. 38	995	40	30. 71	1, 040
51	28. 08	951	96	29. 41	996	41	30. 74	1, 041
52	28. 11	952	97	29. 44	997	42	30. 77	1, 042
53	28. 14	953	98	29. 47	998	43	30. 80	1, 043
54	28. 17	954	99	29. 50	999	44	30. 83	1, 044
55	28. 20	955	00	29. 53	1, 000	45	30. 86	1, 045
56	28. 23	956	01	29. 56	1, 001	46	30. 89	1, 046
57	28. 26	957	02	29. 59	1, 002	47	30. 92	1, 047
58	28. 29	958	03	29. 62	1, 003	48	30. 95	1, 048
59	28. 32	959	04	29. 65	1, 004	49	30. 98	1, 049
60	28. 35	960	05	29. 68	1, 005	50	31. 01	1, 050
61	28. 38	961	06	29. 71	1, 006	51	31. 04	1, 051
62	28. 41	962	07	29. 74	1, 007	52	31. 07	1, 052
63	28. 44	963	08	29. 77	1, 008	53	31. 10	1, 053
64	28. 47	964	09	29. 80	1, 009	54	31. 12	1, 054
65	28. 50	965	10	29. 83	1, 010	55	31. 15	1, 055
66	28. 53	966	11	29. 85	1, 011	56	31. 18	1, 056
67	28. 56	967	12	29. 88	1, 012	57	31. 21	1, 057
68	28. 58	968	13	29. 91	1, 013	58	31. 24	1, 058
69	28. 61	969	14	29. 94	1, 014	59	31. 27	1, 059

NOTE 1.—It will be seen that the code figures may represent two values of barometric pressure, but this takes place only with a very high or very low barometer reading. In such cases the recipients of a message will be able to decide which value is intended. Code figures which correspond closest to exact barometer reading are used.

NOTE 2.—One inch equals 33.86395 millibars; one millibar equals 0.02952993 inch. One millimeter equals 0.039370 inch; one inch equals 25.40005 millimeters. One millimeter equals 1.33322387 millibars; one millibar equals 0.7500616 millimeter.

NOTE 3.—The value placed on the map is the code figure with a 0 annexed; e. g., code figure 66, placed on the map "660".

CODE TABLE 33.—*Symbol C—Form of predominating cloud*

Code figure	Form of cloud	On map	Code figure	Form of cloud	On map
1	Cirrus		6	Stratocumulus	
2	Cirrostratus		7	Nimbostratus	
3	Cirrocumulus		8	Cumulus or fracto-cumulus	
4	Altocumulus		9	Cumulonimbus	
5	Altostratus		0	Stratus or fracto-stratus	—

NOTE.—For symbol D_e use code table 21.

CODE TABLE 34.—*Symbols ww—Present weather*

NOTE.—In coding present weather (ww) the observer will use the highest code figure in this complete table applicable to the weather existing at time of observation.

Code figures 00 to 19.—Abbreviated description of sky and special phenomena.

00 Cloudless (from no clouds up to but not including 1 tenth).
01 Partly cloudy (from exactly 1 tenth to exactly 5 tenths).
02 Cloudy (over 5 tenths up to and including exactly 9 tenths).
03 Overcast (over 9 tenths).
04 Low fog, whether on ground or at sea.
05 Haze (but visibility greater than 1,000 m., 1,100 yds.).
06 Dust devils seen.
07 Distant lightning.
08 Light fog (visibility between 1,000 m. and 9.6 km., or ⅝ mile and 6 miles).
09 Fog at a distance, but not at station (or ship).
10 Precipitation within sight.
11 Thunder, without precipitation at station (or ship).
12 Dust storm within sight, but not at station (or ship).
13 Ugly, threatening sky.
14 Squally weather.
15 Heavy squalls } in last 3 hours.
16 Waterspouts seen } in last 3 hours.
17 Visibility reduced by smoke (industrial, grass or forest fires), or volcanic ashes.

CODE TABLE 34.—*Code figures 00 to 19*—Continued

18	Dust storm (visibility greater than 1,100 yards or ⅝ mile).	
19	Signs of tropical storm (hurricane).	

Code figures 20 to 29.—Precipitation in last hour but not at time of observation.

20	Precipitation (rain, drizzle, hail, snow, or sleet).	
21	Drizzle	other than showers.
22	Rain	
23	Snow	
24	Rain and snow mixed.	
25	Rain shower(s).	
26	Snow shower(s).	
27	Hail or rain and hail shower(s).	
28	Slight thunderstorm.	
29	Heavy thunderstorm.	

Code figures 30 to 39.—Dust storms and storms of drifting snow (visibility less than 1,000 meters, 1,100 yards or ⅝ mile).

30	Dust or sand storm.	
31	Dust or sand storm has decreased.	
32	Dust or sand storm, no appreciable change.	
33	Dust or sand storm has increased.	
34	Line of dust storms.	
35	Storm of drifting snow.	
36	Slight storm of drifting snow	generally low.
37	Heavy storm of drifting snow	
38	Slight storm of drifting snow	generally high.
39	Heavy storm of drifting snow	

Code figures 40 to 49.—Fog (visibility less than 1,000 meters, 1,100 yards or ⅝ mile).

40	Fog.	
41	Moderate fog in last hour	but not at time of observation.
42	Thick fog in last hour	
43	Fog, sky discernible	has become thinner during last hour.
44	Fog, sky not discernible	
45	Fog, sky discernible	no appreciable change during last hour.
46	Fog, sky not discernible	
47	Fog, sky discernible	has begun or become thicker during last hour.
48	Fog, sky not discernible	
49	Fog in patches.	

Code figures 50 to 59.—Drizzle (precipitation consisting of numerous minute drops).

50	Drizzle.	
51	Intermittent	Slight drizzle.
52	Continuous	
53	Intermittent	moderate drizzle.
54	Continuous	
55	Intermittent	thick drizzle.
56	Continuous	

CODE TABLE 34.—*Code figures 50 to 59*—Continued

57 Drizzle and fog.
58 Slight or moderate } drizzle and rain.
59 Thick } drizzle and rain.

Code figures 60 to 69.—Rain.

60 Rain.
61 Intermittent } slight rain.
62 Continuous } slight rain.
63 Intermittent } moderate rain.
64 Continuous } moderate rain.
65 Intermittent } heavy rain.
66 Continuous } heavy rain.
67 Rain and fog.
68 Slight or moderate } rain and snow, mixed.
69 Heavy } rain and snow, mixed.

Code figures 70 to 79.—Snow.

70 Snow (or snow and rain, mixed).
71 Intermittent } slight snow in flakes.
72 Continuous } slight snow in flakes.
73 Intermittent } moderate snow in flakes.
74 Continuous } moderate snow in flakes.
75 Intermittent } heavy snow in flakes.
76 Continuous } heavy snow in flakes.
77 Snow and fog.
78 Grains of snow (frozen drizzle).
79 Ice crystals, or frozen raindrops (sleet—U. S. definition).

Code figures 80 to 89.—Shower(s).

80 Shower(s).
81 Shower(s) of slight or moderate } rain.
82 Shower(s) of heavy } rain.
83 Shower(s) of slight or moderate } snow.
84 Shower(s) of heavy } snow.
85 Shower(s) of slight or moderate } rain and snow.
86 Shower(s) of heavy } rain and snow.
87 Shower(s) of snow pellets (soft hail).
88 Shower(s) of slight or moderate } hail, or rain and hail.
89 Shower(s) of heavy } hail, or rain and hail.

Code figures 90 to 99.—Thunderstorm.

90 Thunderstorm.
91 Rain at time } thunderstorm during last hour but not at time of observation.
92 Snow, or rain and snow mixed, at time } thunderstorm during last hour but not at time of observation.
93 Thunderstorm, slight, without hail but with rain (or snow) } at time of observation.
94 Thunderstorm, slight, with hail } at time of observation.
95 Thunderstorm, moderate, without hail but with rain (or snow) } at time of observation.
96 Thunderstorm, moderate, with hail } at time of observation.
97 Thunderstorm, heavy, without hail but with rain (or snow) } at time of observation.
98 Thunderstorm combined with dust storm } at time of observation.
99 Thunderstorm, heavy, with hail } at time of observation.

CODE TABLE 35.—*Symbol W—Past weather*

Weather	Code figure	Map symbol
Fair (clear or slightly clouded)	0	
Variable sky	1	◐
Mainly overcast	2	●
Sandstorm or dust storm, or storm of drifting snow	3	
Fog or thick dust haze (visibility less than 1,100 yds.)	4	≡
Drizzle	5	,
Rain	6	•
Snow or sleet	7	*
Showers	8	▽
Thunderstorm	9	

CODE TABLE 36.—*Symbol Y—Day of the week*

Day	Code figures	Day	Code figures
unday	1	Thursday	5
ɬonday	2	Friday	6
'uesday	3	Saturday	7
Vednesday	4		

CODE TABLE 37.—*Symbol Q—Octant of the globe*

Longitude	Code figures	Longitude	Code figures
Vorth latitude:		*South latitude:*	
0° W. to 90° W	0	0° W. to 90° W	5
90° W. to 180° W	1	90° W. to 180° W	6
180° E. to 90° E	2	180° E. to 90° E	7
90° E. to 0° E	3	90° E. to 0° E	8

CODE TABLE 38.—*Symbol D_K—Direction from which swell is moving; symbol d_s—Direction toward which ship is moving*

True direction	Code figures	True direction	Code figures
No sea or swell, or ship hove to	0	South	4
Northeast	1	Southwest	5
East	2	West	6
Southeast	3	Northwest	7
		North	8

NOTE.—Arrow points to direction sea swell is moving.

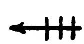
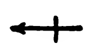
CODE TABLE 39.—*Symbol T_d—Temperature difference of air and water*

[Difference between temperatures of air and water at or near surface]

Code figures	Difference	Relation	On map (Sea temp.)[1]
0	More than 9° F	Air temperature is same as or higher than sea temperature.	−9
1	6° to 9°		−7
2	3° to 6°		−4
3	1° to 3°		−2
4	No difference, or less than 1° F.		0
5	Less than 1° F	Air temperature is lower than sea temperature.	+1
6	1° to 3°		+2
7	3° to 6°		+4
8	6° to 9°		+7
9	More than 9°		+9

[1] Add to or subtract from the code figure for temperature of air, TT.

CODE TABLE 40.—*Symbol K—Sea swell*

Code figure[1]	Swell	On map
0	No swell	
1	Low swell, short or average length	
2	Low swell, long	
3	Moderate swell, short	
4	Moderate swell, average length	
5	Moderate swell, long	
6	Heavy swell, short	
7	Heavy swell, average length	
8	Heavy swell, long	
9	Confused swell	

[1] When plotting on the synoptic chart, show the direction from which swell is coming. (Arrow points in direction to which the swell is moving.)

CODE TABLE 41.—*Symbol v_s—Ship speed*

Code figure	Speed	On map	Code figure	Speed	On map
0	Ship stopped	0	5	13 to 15 knots	13
1	1 to 3 knots	1	6	16 to 18 knots	16
2	4 to 6 knots	4	7	19 to 21 knots	19
3	7 to 9 knots	7	8	22 to 24 knots	22
4	10 to 12 knots	10	9	More than 24 knots	25

NOTE.—For speed to place on map, multiply code figure by 3 and subtract 2.

CODE TABLE 42.—*Symbol S—State of sea*

Code figure	Description	Height of wave, crest to trough
0	Calm	0.
1	Smooth	Less than 1 foot.
2	Slight	1 to 3 feet.
3	Moderate	3 to 5 feet.
4	Rough	5 to 8 feet.
5	Very rough	8 to 12 feet.
6	High	12 to 20 feet.
7	Very high	20 to 40 feet.
8	Precipitous	Over 40 feet.
9	Confused	

CODE TABLE 43.—*Stations located in islands south of 20° north latitude (Caribbean islands)*

Index No.	Name of station	Latitude Deg.	Latitude Min. (N.)	Longitude Deg.	Longitude Min. (W.)	Altitude Feet
000						
001	Willemstadt, Curaçao	12	06	68	56	
002	Port of Spain, Trinidad	10	38	61	30	
003	Grenada	12	07	61	46	
004	Bridgetown, Barbados	13	04	59	37	
005	Castries, St. Lucia	14	02	61	00	
006	Fort-de-France, Martinique	14	36	61	04	
007	Roseau, Dominica	15	16	61	23	
008	Pointe-à-Pitre, Guadeloupe	16	15	61	32	
009	St. Johns, Antigua	17	06	61	50	
010	Basseterre, St. Kitts	17	18	62	43	
011	Phillipsburg, St. Martin	18	01	63	04	
012	Christiansted, St. Croix	17	45	64	42	
013	St. Thomas, Virgin Islands	18	20	64	55	
014						
015	San Juan, Puerto Rico	18	28	66	07	82

CODE TABLE 43.—*Stations located in islands south of 20° north latitude (Caribbean islands)*—Continued

Index No.	Name of station	Latitude Deg.	Latitude Min. (N.)	Longitude Deg.	Longitude Min. (W.)	Altitude Feet
016	Ciudad Trujillo, Dominican Republic	18	28	69	53	83
017	Puerto Plata, Dominican Republic	19	49	70	43	--------
018	Port-au-Prince, Haiti	18	35	72	20	--------
019	------	------		------		--------
020	------	------		------		--------
021	Kingston, Jamaica	18	00	76	51	--------
022	------	------		------		--------
023	Grand Cayman, West Indies	19	15	81	25	--------
024	Swan Island, West Indies	17	22	83	57	33
	Stations located in Cuba					
025	------	------		------		--------
026	Guane	22	11	84	05	--------
027	San Juan y Martinez	22	17	83	50	--------
028	Pinar del Rio	22	25	83	42	--------
029	Nueva Gerona, Isle of Pines	21	53	82	48	--------
030	Havana	23	09	82	21	292
031	------	------		------		--------
032	Cienfuegos	22	09	80	27	--------
033	Sagua la Grande	22	48	80	04	--------
034	Santa Clara	22	25	79	57	--------
035	Tunas de Zaza	21	39	79	33	--------
036	Cairbarien	22	32	79	30	--------
037	Jucaro	21	38	78	52	--------
038	Cayo Paredon Grande	22	29	78	10	--------
039	Camaguey	21	24	77	55	--------
040	------	------		------		--------
041	Niquero	20	03	77	35	--------
042	Nuevitas	21	33	77	16	--------
043	Gibara	21	07	76	08	--------
044	Santiago de Cuba	20	01	75	50	--------
045	------	------		------		--------
046	Daiquiri	19	54	75	36	--------
047	Guantanamo Bay	19	57	75	08	--------
048	Baracoa	20	22	74	30	--------
049	------	------		------		--------
	Stations located in islands north of 20° north latitude (Turks Island, Bahamas, and Bermuda)					
050	Turks Island	21	30	71	02	--------
051	Matthew Town, St. Inagua	20	56	73	41	--------
052	Abraham Bay, Mayaguana	22	21	72	50	--------
053	Long Cay, Crooked Island	23	36	74	25	--------
054	Duncantown, Ragged Island	22	11	75	45	--------
055	Clarance Town, Long Island	23	05	75	00	--------
056	George Town, Exuma	23	30	75	46	--------

ODE TABLE 43.—*Stations located in islandsn orth of 20° north latitude (Turks Island, Bahamas, and Bermuda)*—Continued

Index No.	Name of station	Latitude Deg.	Latitude Min. (N.)	Longitude Deg.	Longitude Min. (W.)	Altitude Feet
57	Riding Rock, San Salvador	24	05	74	31	--------
58	The Bight, Cat Island	24	15	75	20	--------
59	Mangrove Cay, Andros Is	24	13	77	36	--------
60	------------------------------	------		------		--------
61	Nassau, New Providence	25	03	77	20	8
62	Governor's Harbor, Eleuthera	25	12	76	16	--------
63	Hatchet Bay, Eleuthera	25	21	76	28	--------
64	Harbour Island, Eleuthera	25	30	76	39	--------
65	Whale Cay, Berry Island	25	25	77	46	--------
66	North Cat Cay, Great B. Bank	25	34	79	18	--------
67	Alice Town, Bimini	25	44	79	19	--------
68	Cherokee Sound, Great Abaco	26	16	77	05	--------
69	Hope Town, Great Abaco	26	32	76	57	--------
070	Green Turtle Cay, G. A	26	46	77	20	--------
071	West End, Grand Bahama	26	41	79	00	--------
072	------------------------------	------		------		--------
073	------------------------------	------		------		--------
074	St. George, Bermuda	32	23	64	41	158

Stations located in Central America: Panama, Costa Rica, Nicaragua, Honduras, Salvador, Guatemala, British Honduras

Index No.	Name of station	Latitude Deg.	Latitude Min. (N.)	Longitude Deg.	Longitude Min. (W.)	Altitude Feet
075	------------------------------	------		------		--------
076	Balboa (Panama), Canal Zone	8	58	79	35	--------
077	Colon (Coco Solo), Canal Zone	9	22	79	53	--------
078	------------------------------	------		------		--------
079	David, Panama	8	29	82	27	--------
080	------------------------------	------		------		--------
081	------------------------------	------		------		--------
082	San Jose, Costa Rica	9	58	84	02	--------
083	------------------------------	------		------		--------
084	------------------------------	------		------		--------
085	Managua, Nicaragua	12	10	86	15	--------
086	Bluefields, Nicaragua	12	00	83	45	--------
087	------------------------------	------		------		--------
088	Cape Gracias, Nicaragua	15	00	83	10	--------
089	------------------------------	------		------		--------
090	Tegucigalpa, Honduras	14	15	87	08	--------
091	------------------------------	------		------		--------
092	Tela, Honduras	15	45	87	28	--------
093	------------------------------	------		------		--------
094	San Salvador, Salvador	13	43	89	09	--------
095	------------------------------	------		------		--------
096	Guatemala, Guatemala	14	42	88	35	--------
097	Puerto Barrios, Guatemala	15	42	88	35	--------
098	------------------------------	------		------		--------
099	Belize, British Honduras	17	30	88	12	--------

CODE TABLE 43.—*Stations located in Mexico*

Index No.	Name of station	Latitude Deg.	Latitude Min. (N.)	Longitude Deg.	Longitude Min. (W.)	Altitude Feet
100	Chetumal, Q. R	18	30	88	18	13
101	Cozumel, Q. R	20	31	86	57	26
102	Isla Mujeres, Q. R	21	12	86	43	23
103	Valladolid, Yuc	20	41	88	12	72
104	Champoton, Camp	19	21	90	43	7
105	Campeche, Camp	19	51	90	32	26
106	Merida, Yuc	20	59	89	39	30
107	Progreso, Yuc	21	17	89	40	7
108	Tapachula, Chis	14	55	92	16	449
109	Comitan, Chis	16	15	92	08	5, 236
110	Tenosique, Tab	17	29	91	26	197
111	Ciudad Las Casas, Chis	16	44	92	38	6, 857
112	Tuxtla Gutierrez, Chis	16	45	93	07	1, 739
113	Tonala, Chis	16	05	93	45	131
114	Teapa, Tab	17	33	92	57	164
115	Villahermosa, Tab	17	59	92	55	33
116	Ciudad Obregon, Tab	18	32	92	39	7
117	Cintalapa, Chis	16	42	93	45	1, 788
118	Salina Cruz, Oax	16	10	95	12	13
119	Coatzacoalcos, Ver	18	09	94	25	43
120	Oaxaca, Oax	17	04	96	43	5, 072
121	Veracruz, Ver	19	12	96	08	10
122	Huajuapan, Oax	17	49	97	46	5, 118
123	Orizaba, Ver	18	51	97	06	4, 213
124	Cordoba, Ver	18	54	96	56	3, 032
125	Jalapa, Ver	19	32	96	55	4, 465
126	Tuxpan, Ver	20	57	97	24	13
127	Tehuacan, Pue	18	28	97	24	5, 407
128	Piaxtla, Pue	18	12	98	16	3, 789
129	Puebla, Pue	19	03	98	12	7, 093
130	Tlaxcala, Tlax	19	19	98	14	7, 388
131	Tulancingo, Hgo	20	05	98	22	7, 310
132	Huauchinango, Pue	20	11	98	03	4, 888
133	Chilpancingo, Gro	17	33	99	30	4, 232
134	Iguala, Gro	18	21	99	32	1, 978
135	Cuernavaca, Mor	18	54	99	14	5, 059
136	Tacubaya, D. F	19	24	99	12	7, 575
137	Pachuca, Hgo	20	08	98	44	7, 959
138	Acapulco, Gro	16	50	99	50	10
139	Huetamo, Mich	18	40	100	54	1, 168
140	Tula, Hgo	20	03	99	21	6, 660
141	Toluca, Mex	19	18	99	40	8, 661
142	Zitacuaro	19	26	100	22	6, 499
143	La Union, Gro	17	58	101	48	98
144	Morelia, Mich	19	42	101	07	6, 189
145	Queretaro, Qro	20	36	100	23	5, 974
146	Ciudad Obergon, Gto	21	00	100	24	6, 516

CODE TABLE 43.—*Stations located in Mexico*—Continued

Index No.	Name of station	Latitude Deg.	Latitude Min. (N.)	Longitude Deg.	Longitude Min. (W.)	Altitude Feet
147	Rioverde, S. L. P	21	56	100	00	3, 251
148	Tampico, Tamps	22	13	97	51	39
149	Arteaga, Mich	18	31	102	33	3, 957
150	Zamora, Mich	19	59	102	18	5, 141
151	Guanajuato, Gto	21	01	101	15	6, 588
152	Leon, Gto	21	07	101	41	5, 860
153	San Luis Potosi, S. L. P	22	09	100	59	6, 158
154	Soto La Marina, Tamps	23	46	98	12	82
155	Ciudad Vicoria, Tamps	23	44	99	10	1, 053
156	Colima, Col	19	14	103	43	1, 503
157	Aguascalientes, Ags	21	53	102	18	6, 194
158	Charcas, S. L. P	23	08	101	07	6, 749
159	Matamoros, Tamps	25	53	97	31	131
160	Manzanillo, Col	19	04	104	20	16
161	Guadalajara, Jal	20	41	103	21	5, 052
162	Zacatecas, Zac	22	47	102	34	8, 012
163	Linares, N. L	24	52	99	34	2, 244
164	Monterrey, N. L	25	40	100	18	1, 765
165	Puerto Vallarta, Jal	20	37	105	15	7
166	Mascota, Jal	20	33	104	45	4, 380
167	Sombrereto, Zac	23	29	103	37	7, 713
168	Saltillo, Coah	25	26	101	00	5, 213
169	Monclova, Coah	26	54	101	25	1, 926
170	Ciudad Lerdo, Dgo	25	32	103	31	3, 724
171	Nazas, Dgo	25	14	104	07	4, 177
172	Durango, Dgo	24	02	104	40	6, 198
173	Topic, Nay	21	31	104	54	3, 035
174	San Blas, Nay	21	32	105	17	23
175	Islas Marias, Nay	21	35	106	30	13
176	Sierra Mojada, Coah	27	17	103	42	5, 134
177	Ciudad Camargo, Chih	27	42	105	10	5, 423
178	Chihuahua, Chih	28	38	106	05	4, 692
179	Villa Ahumada, Chih	30	37	106	31	3, 875
180	Mazatlan, Sin	23	11	106	26	10
181	San Ignacio, Sin	23	56	106	26	492
182	S. Papasquiare, Dgo	25	02	105	26	5, 630
183	Tepehuanes, Dgo	25	20	105	43	5, 863
184	Hidalgo del Parral, Chih	26	56	105	40	5, 449
185	Culiacan, Sin	24	49	107	24	171
186	Badiraguato, Sin	25	22	107	29	600
187	Temosachic, Chih	28	57	107	50	6, 234
188	Topolobampo, Sin	25	36	109	03	10
189	Choix, Sin	26	43	108	16	1, 198
190	La Paz, B. C	24	10	110	21	43
191	Navejea, Son	27	07	109	28	98
192	Ciudad Obregon, Son	27	29	109	55	230
193	Ures, Son	29	26	110	24	909

CODE TABLE 43.—*Stations located in Mexico*—Continued

Index No.	Name of station	Latitude Deg. (N.)	Latitude Min. (N.)	Longitude Deg. (W.)	Longitude Min. (W.)	Altitude Feet
194	Guaymas, Son	27	55	110	54	13
195	Hermosillo, Son	29	04	110	58	778
196	Bahia Magdalena, B. C	24	39	112	09	39
197	Santa Rosalia, B. C	27	14	112	17	66
198	Altar, Son	30	44	111	46	1, 302
199	Ensenada, B. C	31	52	116	38	26

International index numbers for North America

Index No.	Name of station	Latitude north Deg.	Latitude north Min.	Longitude west Deg.	Longitude west Min.	Altitude (Hb) Feet
200						
201	Key West, Fla	24	33	81	47	11
202	Miami, Fla	25	55	80	17	12
203	West Palm Beach, Fla	26	42	80	04	21
204	Melbourne, Fla	28	05	80	34	27
205						
206	Jacksonville, Fla	30	25	81	39	31
207	Savannah, Ga	32	05	81	05	44
208	Charleston, S. C	32	34	80	02	48
209						
210	Ft. Myers, Fla	26	39	81	52	12
211	Tampa, Fla	27	55	82	27	11
212	Ocala, Fla	29	10	82	05	71
213	Thomasville, Ga	30	48	83	58	273
214	Tallahassee, Fla	30	27	84	20	68
215	Alma, Ga	31	32	82	31	206
216	Albany, Ga	31	33	84	11	193
217	Macon, Ga	32 [1]	50	83	38	464
218	Augusta, Ga	33	29	82	02	426
219	Atlanta, Ga	33	39	84	25	976
220	Apalachicola, Fla	29	45	84	58	35
221						
222	Pensacola, Fla	30	21	87	16	90
223	Mobile, Ala	30	38	88	04	31
224	Dotham, Ala	31	12	85	22	353
225	Evergreen, Ala	31	25	87	02	257
226	Montgomery, Ala	32	24	86	14	237
227						
228	Birmingham, Ala	33	34	86	45	630
229						
230	Port Eads, La	29	01	89	10	7
231	New Orleans, La	30	02	90	04	30
232						
233	Tylertown, Miss	31	03	90	03	395
234	Meridian, Miss	32	21	88	40	375
235	Jackson, Miss	32	20	90	13	330

[1] Approximate.

Code Table 43.—*International index numbers for North America*—Continued

Index No.	Name of station	Latitude north Deg.	Latitude north Min.	Longitude west Deg.	Longitude west Min.	Altitude (Hb) Feet
236	Vicksburg, Miss	32	24	90	48	263
237	Monroe, La	32	32	92	04	81
238	Greenwood, Miss	33	30	90	11	133
239	Monticello, Ark	33	36	91	47	305
240	Lake Charles, La	30	13	93	09	32
2/4	Arcadia, La	32	31	92	55	400
241	Port Arthur, Tex	29	52	93	56	34
242	Galveston, Tex	29	16	94	52	9
243	Houston, Tex	29	39	95	17	62
244	Navasota, Tex	30	24	96	04	337
245	Lufkin, Tex	31	21	94	45	316
246	Alexandria, La	31	18	92	27	84
247	Palestine, Tex	31	45	95	40	510
248	Shreveport, La	32	33	93	46	181
249	Sulphur Springs, Tex	33	10	95	36	488
2/5	Fredericksburg, Tex	30	16	98	52	[1] 1, 712
250	Brownsville, Tex	25	55	97	28	18
251	Corpus Christi, Tex	27	45	97	25	44
252	Laredo, Tex	27	33	99	28	418
253	San Antonio, Tex	29	27	98	28	582
254	Austin, Tex	30	19	97	42	621
255	Palacios, Tex	28	45	96	17	15
256	Waco, Tex	31	33	97	06	578
257	Brady, Tex	31	08	99	21	1, 728
258	Dallas, Tex	32	51	96	52	488
259	Fort Worth, Tex	32	49	97	21	706
260	Crystal City, Tex	28	43	99	50	[1] 571
261	Del Rio, Tex	29	20	100	53	960
262	Alpine, Tex	30	21	103	40	4, 579
263	Eldorado, Tex	30	53	100	32	2, 433
264	Wink, Tex	31	47	103	13	2, 813
265	Big Spring, Tex	32	14	101	30	2, 537
266	Abilene, Tex	32	26	99	41	1, 750
267	Lubbock, Tex	33	38	101	49	3, 241
268	Roswell, N. Mex	33	24	104	27	3, 566
269	Carrizozo, N. Mex	33	39	105	52	5, 424
270	El Paso, Tex	31	48	106	24	3, 916
271	------	---	---	---	---	------
272	Rodeo, N. Mex	31	56	109	00	4, 126
273	------	---	---	---	---	------
274	Tucson, Ariz	32	07	110	55	2, 555
275	Engle, N. Mex	33	12	107	02	4, 779
276	Mogollon, N. Mex	33	24	108	48	6, 566
277	------	---	---	---	---	------
278	Phoenix, Ariz	33	26	112	03	1, 112
279	------	---	---	---	---	------

[1] Approximate.

CODE TABLE 43.—*International index numbers for North America*—Continued

Index No.	Name of station	Latitude north Deg.	Latitude north Min.	Longitude west Deg.	Longitude west Min.	Altitude (Hb) Feet
280	Yuma, Ariz	32	45	114	36	141
281						
282						
283	Blythe, Calif	33	36	114	39	264
284						
285						
286	Pomona, Calif	34	04	117	44	
287						
288	Burbank, Calif	34	12	118	22	725
289	Mt. Wilson, Calif	34	14	118	04	5, 711
290	San Diego, Calif	32	44	117	10	28
291	San Nicolas Island, Calif	33	15	119	48	137
292	Buffalo Springs, Calif	33	24	118	21	1, 633
293	San Pedro, Calif	33	44	118	17	32
294	Point Fermin, Calif	33 [1]	43	118 [1]	17	
295	Los Angeles, Calif	34	03	118	15	338
296	San Clemente Island, Calif	32 [1]	50	118 [1]	30	
297						
298						
299	San Miguel Island, Calif	34	03	120	21	550
30/	Elizabeth City, N. C	36 [1]	19	76 [1]	14	[1] 10
300	Florence, S. C	34	09	79	43	151
301	Wilmington, N. C	34	14	77	57	72
302	Cape Lookout, N. C	34	36	76	32	5
303	Fort Bragg, N. C	35	11	79	01	199
304	Hatteras, N. C	35	15	75	40	11
305	Greenville, N. C	35	37	77	25	55
306	Raleigh, N. C	35	45	78	37	365
307	Cape Henry, Va	36	56	76	00	18
308	Norfolk, Va	36	53	76	12	30
309						
310	Columbia, S. C	34	00	81	03	225
311						
312	Greenville, S. C	34	50	82	24	1, 040
313	Spartanburg, S. C	34	58	81	57	824
314	Charlotte, N. C	35	13	80	56	769
315	Asheville, N. C	35	36	82	32	2, 253
316	Mt. Mitchell, N. C	35	46	82	16	6, 684
317	Greensboro, N. C	36	05	79	57	886
318	Bristol, Tenn	36	29	82	21	1, 525
319						
320						
321						
322	Muscle Shoals, Ala	34	46	87	38	545
323	Huntsville, Ala	34	43	86	35	644
324	Chattanooga, Tenn	35	04	85	18	762

[1] Approximate.

Code Table 43.—*International index numbers for North America*—Continued

Index No.	Name of station	Latitude north Deg.	Latitude north Min.	Longitude west Deg.	Longitude west Min.	Altitude (Hb) Feet
325						
326	Knoxville, Tenn	35	49	83	59	980
327	Nashville, Tenn	36	07	86	41	605
328	Stearns, Ky	36	48	84	09	1, 420
329						
330	Tupelo, Miss	34	15	88	25	306
331						
332						
333						
334	Memphis, Tenn	35	03	89	59	284
335	Batesville, Ark	35	49	91	37	363
336						
337	Paris, Tenn	36	18	88	23	504
338	Cairo, Ill	37	00	89	10	358
339						
340	Little Rock, Ark	34	45	92	16	265
341						
342	McAlester, Okla	34	55	95	46	744
343						
344	Ft. Smith, Ark	35	22	94	24	463
345						
346						
347	Bentonville, Ark	36	22	94	12	1, 303
348	West Plains, Mo	36	44	91	52	1, 011
349						
350	Ardmore, Okla	34	19	97	09	866
351	Wichita Falls, Tex	33	54	98	31	1, 030
352	Quanah, Tex	34	17	99	41	1, 585
353	Oklahoma City, Okla	35	34	97	36	1, 304
354						
355	Elk City, Okla	35	22	99	23	1, 962
356	Tulsa, Okla	36	11	95	54	674
357	Ponca City, Okla	36	46	97	06	998
358	Waynoka, Okla	36	38	98	50	1, 533
359						
360						
361						
362						
363	Amarillo, Tex	35	15	101	44	3, 604
364	Tucumcari, N. Mex	35	11	103	36	4, 039
365	Albuquerque, N. Mex	35	03	106	37	5, 314
366	Santa Fe, N. Mex	35	39	106	03	6, 676
367	Clayton, N. Mex	36	27	103	12	5, 052
368	Guymon, Okla	36	41	101	28	3, 128
369						
370						
371						

Code Table 43.—*International index numbers for North America*—Continued

Index No.	Name of station	Latitude north Deg.	Latitude north Min.	Longitude west Deg.	Longitude west Min.	Altitude (Hb) Feet
372	Prescott, Ariz	34	30	112	28	5, 387
373	El Morro, N. Mex	35	21	108	26	7, 121
374	Winslow, Ariz	35	00	110	50	4, 880
375	Flagstaff, Ariz	35	12	111	37	6, 921
376	Farmington, N. Mex	36	44	108	13	5, 374
377	Crownpoint, N. Mex	35	40	108	13	6, 978
378	Grand Canyon, Ariz	35	51	112	04	6, 367
379						
380	Needles, Calif	34	50	114	36	488
381	Kingman, Ariz	35	15	114	01	3, 435
382						
383	Sandberg, Calif	34	45	118	44	4, 523
384	Bakersfield, Calif	35	25	119	03	492
385	Silver Lake, Calif	35	22	116	07	918
386	Las Vegas, Nev	36	14	115	02	1, 869
387						
388	Independence, Calif	36	48	118	12	3, 957
389	Fresno, Calif	36	43	119	49	282
390	Point Hueneme, Calif	34	09	119	12	16
391	Santa Barbara, Calif	34	26	119	44	20
392	Point Arguello, Calif	34	35	120	39	112
393	Taft, Calif	35	10	119	25	75
394						
395	Estero, Calif	35	26	120	52	[1] 6
396	Pt. Piedras Blancas, Calif	35	40	121	17	69
397	Coalinga, Calif	36	09	120	21	676
398	King City, Calif	36	13	121	08	320
399	Hollister, Calif	36	53	121	24	365
400	Urbana, Va	37	36	76	34	25
401	Richmond, Va	37	30	77	20	161
402	Snow Hill, Md	38	10	75	23	25
403	Cape May, N. J	38	56	74	45	10
404	Delaware Breakwater, Del	38	48	75	06	20
405	Washington, D. C	38	52	77	03	15
406	Baltimore, Md	39	15	76	31	16
407	Atlantic City, N. J	39	22	74	25	52
408	Philadelphia, Pa	39	57	75	09	114
409	Lakehurst, N. J	40	02	74	19	128
410	Lynchburg, Va	37	20	79	12	937
411	Roanoke, Va	37	16	79	58	1, 169
412	Flat Top, W. Va	37	35	81	06	3, 270
413	Pikeville, Ky	37	32	82	32	700
414	Charleston, W. Va	38	23	81	46	606
415	Clarksburg, W. Va	39	17	80	14	1, 184
416	Gordonsville, Va	38	10	78	10	442
417	Elkins, W. Va	38	56	79	51	2, 006
418	Frostburg, Md	39	40	78	58	2, 852

[1] Approximate.

CODE TABLE 43.—*International index numbers for North America*—Continued

Index No.	Name of station	Latitude north Deg.	Latitude north Min.	Longitude west Deg.	Longitude west Min.	Altitude (Hb) Feet
19						
/2	Chillicothe, Ohio	39	[1] 25	82	[1] 54	[1] 850
20	Smith's Grove, Ky	37	04	86	11	645
21	Winchester, Ky	37	55	84	16	989
22						
23	Louisville, Ky	38	13	85	40	545
24	Cherry Fork, Ohio	38	50	83	34	944
25	Huntington, W. Va	38	25	82	30	565
126	Cincinnati, Ohio	39	06	84	25	497
127	Parkersburg, W. Va	39	16	81	36	637
128	Columbus, Ohio	40	00	82	53	833
129	Dayton, Ohio	39	46	84	12	900
130						
431	Advance, Mo	37	04	89	55	359
432	Evansville, Ind	37	38	87	32	388
433	Carbondale, Ill	37	44	89	10	463
434	St. Louis, Mo	38	45	90	23	564
435	Washington, Ind	38	39	87	11	543
436	Effingham, Ill	39	09	88	33	614
437	Terre Haute, Ind	39	29	87	24	485
438	Indianapolis, Ind	39	44	86	16	808
439	Springfield, Ill	39	45	89	41	613
440	Springfield, Mo	37	13	93	15	1, 360
441	Chanute, Kans	37	40	95	30	981
442	Rolla, Mo	37	57	91	46	1, 205
443	Clinton, Mo	38	20	93	42	790
444						
445	Columbia, Mo	38	57	92	20	785
446	Kansas City, Mo	39	05	94	37	750
447						
448						
449	St. Joseph, Mo	39	46	94	55	817
450	Wichita, Kans	37	38	97	17	1, 392
451	Dodge City, Kans	37	45	100	00	2, 509
452	Lebo, Kans	38	26	95	47	1, 164
453						
454	Geneseo, Kans	38	31	98	11	1, 760
455	Ellis, Kans	38	56	99	34	2, 157
456	Topeka, Kans	39	03	95	41	987
457						
458	Concordia, Kans	39	35	97	41	1, 392
459	Phillipsburg, Kans	39	45	99	18	1, 936
460	Trinidad, Col	37	16	104	20	5, 743
461	Monte Vista, Col	37	36	106	09	7, 663
462						
463	Lamar, Col	38	05	102	35	3, 620

[1] Approximate.

CODE TABLE 43.—*International index numbers for North America*—Continued

Index No.	Name of station	Latitude north Deg.	Latitude north Min.	Longitude west Deg.	Longitude west Min.	Altitude (Hb) Feet
464	Pueblo, Col	38	16	104	36	4,806
465	Goodland, Kans	39	21	101	42	3,688
466						
467	Leadville, Col	39	15	106	18	10,158
468						
469	Denver, Col	39	46	104	53	5,299
470						
471	Durango, Col	37	17	107	53	6,552
472	Blanding, Utah	37	38	109	28	6,039
473	Modena, Utah	37	48	113	54	5,473
474						
475	Milford, Utah	38	24	113	01	5,097
476	Grand Junction, Colo.	39	04	108	34	4,602
477	Green River, Utah	39	00	110	09	4,083
478						
479	Delta, Utah	39	23	112	33	4,714
480						
481	Merced, Calif	37	18	120	29	
482	Stockton, Calif	37	57	121	14	
483	Sacramento, Calif	38	35	121	30	23
484	Hawthorne, Nev	38	33	118	36	4,168
485	Tonopah, Nev	38	04	117	12	6,090
486	Ely, Nev	39	17	114	52	6,262
487	Austin, Nev	39	29	117	05	6,658
488	Reno, Nev	39	30	119	47	4,400
489						
490	Mount Hamilton, Calif	37	20	121	40	4,213
491	Monterey, Calif	36	35	121	50	152
492	Point Montara, Calif	37	32	122	31	[1] 64
493	Oakland, Calif	37	44	122	12	7
494	San Francisco, Calif	37	37	122	23	18
495	S. E. Farallon Island, Calif	37	40	123	00	41
496	Point Reyes, Calif	38	[1] 00	123	[1] 00	[1] 260
497						
498	Williams, Calif	39	05	122	09	129
499	Point Arena, Calif	38	55	123	43	238
4/1	Quantico, Va	38	33	77	20	
500	Sandy Hook, N. J	40	28	74	01	15
501	Trenton, N. J	40	13	74	46	190
502	Newark, N. J	40	42	74	10	30
503	New York, N. Y	40	46	73	52	52
504	New Haven, Conn	41	16	72	54	13
505	Block Island, R. I	41	10	71	36	26
506	Nantucket, Mass	41	17	70	06	12
507	Providence, R. I	41	44	71	25	62
508	Hartford, Conn	41	44	72	39	21

[1] Approximate.

Code Table 43.—*International index numbers for North America*—Continued

Index No.	Name of station	Latitude north Deg.	Latitude north Min.	Longitude west Deg.	Longitude west Min.	Altitude (Hb) Feet
509	Boston, Mass	42	22	71	02	29
5/1	Oneonta, N. Y	42	27	75	04	1, 163
510	Reading, Pa	40	20	75	58	323
511	Harrisburg, Pa	40	13	76	41	351
512	Kylertown, Pa	41	00	78	10	1, 688
513	Wilkes-Barre, Pa	41	18	75	55	549
514	Scranton, Pa	41	24	75	42	805
515	Binghamton, N. Y	42	06	75	55	871
516	Elmira, N. Y	42	10	76	54	948
517	Ithaca, N. Y	42	27	76	29	836
518	Albany, N. Y	42	45	73	48	292
519	Syracuse, N. Y	43	04	76	16	408
520	Pittsburgh, Pa	40	21	79	56	1, 273
5/2	Kane, Pa	41	39	78	48	1, 938
521	Akron, Ohio	41	02	81	27	1, 052
522	----------	---	---	---	---	--------
523	Sandusky, Ohio	41	25	82	40	629
524	Cleveland, Ohio	41	24	81	51	805
525	Mercer, Pa	41	17	80	12	1, 296
526	Erie, Pa	42	05	80	12	737
527	Knapp Creek, N. Y	42	00	78	31	2, 344
528	Buffalo, N. Y	42	56	78	44	706
529	Rochester, N. Y	43	07	77	40	555
530	Lafayette, Ind	40	25	86	56	637
531	Chanute Field, Ill	40	20	88	10	744
532	Peoria, Ill	40	43	89	36	662
533	Fort Wayne, Ind	41	10	85	08	828
534	Chicago, Ill	41	47	87	44	623
535	South Bend, Ind	41	42	86	16	773
536	Toledo, Ohio	41	34	83	28	628
537	Detroit, Mich	42	24	83	00	626
538	Windsor, Ontario	42	[1] 19	83	[1] 03	--------
539	Lansing, Mich	42	47	84	36	874
540	Kirksville, Mo	40	06	92	32	965
541	Keokuk, Iowa	40	22	91	26	614
542	Mount Ayr, Iowa	40	43	94	15	1, 214
543	Iowa City, Iowa	41	38	91	34	653
544	Moline, Ill	41	27	90	31	594
545	Davenport, Iowa	41	30	90	38	606
546	Des Moines, Iowa	41	32	93	39	963
547	Dubuque, Iowa	42	30	90	40	699
548	Iowa Falls, Iowa	42	31	93	16	1, 147
549	Mason City, Iowa	43	09	93	15	1, 168
5/4	Burlington, Iowa	40	[1] 48	91	[1] 08	--------
550	----------	---	---	---	---	--------
551	Lincoln, Nebr	40	51	96	47	1, 189

[1] Approximate.

CODE TABLE 43.—*International index numbers for North America*—Continued

Index No.	Name of station	Latitude north Deg.	Latitude north Min.	Longitude west Deg.	Longitude west Min.	Altitude (Hb) Feet
552	Grand Island, Nebr	40	59	98	18	1, 856
553	Omaha, Nebr	41	18	95	54	982
554						
555	Burwell, Nebr	41	48	99	09	2, 180
556						
557	Sioux City, Iowa	42	30	96	24	1, 103
558	Tyndall, S. Dak	43	00	97	52	1, 422
559						
560	Akron, Colo	40	10	103	10	4, 621
561						
562	North Platte, Nebr	41	08	100	45	2, 787
563	Sidney, Nebr	41	08	102	59	4, 137
564	Cheyenne, Wyo	41	08	104	48	6, 139
565	Parco, Wyo	41	49	107	04	6, 564
566						
567	Valentine, Nebr	42	50	100	32	2, 598
568	Chadron, Nebr	42	51	103	00	3, 439
569	Casper, Wyo	42	55	106	20	5, 290
570	Roosevelt, Utah	40	18	109	59	5, 106
571	Craig, Colo	40	31	107	32	6, 197
572	Salt Lake City, Utah	40	46	111	57	4, 227
573	Fort Bridger, Wyo	41	24	110	24	7, 024
574	Rock Springs, Wyo	41	37	109	13	6, 374
575						
576	Lander, Wyo	42	50	108	45	5, 352
577	Big Piney, Wyo	42	32	110	07	6, 820
578	Pocatello, Idaho	42	55	112	31	4, 478
579	Burley, Idaho	42	32	113	43	4, 157
580	Humboldt, Nev	40	06	118	09	4, 160
581	Wendover, Utah	40	44	114	02	4, 239
582	Elko, Nev	40	55	115	45	5, 077
583	Winnemucca, Nev	40	58	117	43	4, 344
584	Susanville, Calif	40	25	120	39	4, 268
585						
586						
587	Owyhee, Nev	41	57	116	07	5, 401
588						
589	Lakeview, Oreg	42	12	120	21	4, 764
590	Fort Bragg, Calif	39	27	123	48	74
591						
592	Redding, Calif	40	35	122	24	722
593	Blunts Reef Lightship	40	26	124	30	
594	Eureka, Calif	40	48	124	11	60
595	Mt. Shasta, Calif	41	17	122	18	3, 589
596						
597	Medford, Oreg	42	23	122	52	1, 329
598	Brookings, Oreg	42	03	124	17	151

Code Table 43.—*International index numbers for North America*—Continued

Index No.	Name of station	Latitude north Deg.	Latitude north Min.	Longitude west Deg.	Longitude west Min.	Altitude (Hb) Feet
599						
600	Sable Island, N. S	43	56	60	02	25
601	Halifax, N. S	44	39	63	36	240
602						
603	Yarmouth, N. S	43	50	66	02	101
604						
605	Concord, N. H	43	12	71	31	346
606	Portland, Me	43	39	70	15	103
607	Bangor, Me	44	46	68	49	160
608	Eastport, Me	44	54	66	59	75
609	St. Johns, N. B	45	17	66	04	119
610	Whitehall, N. Y	43	35	73	22	304
6/1	Athol, Mass	42	34	72	08	1, 317
611	Lebanon, N. H	43	32	72	16	1, 125
612	Newport, Vt	44	56	72	13	738
613	Mt. Washington, N. H	44	16	71	18	6, 274
614	Northfield, Vt	44	10	72	41	876
615	Whiteface Mountain, N. Y	44	22	73	55	4, 870
616	Lake Placid, N. Y	44	17	73	59	1, 853
617	Burlington, Vt	44	29	73	11	340
618	Rumford, Me	44	30	70	34	674
619	Greenville, Me	45	28	69	36	1, 070
620	Oswego, N. Y	43	27	76	31	335
621						
622	Canton, N. Y	44	35	75	10	448
623	London, Ont	43	02	81	09	912
624	Toronto, Ont	43	40	79	24	379
625	Stirling, Ont	44	19	77	33	
626	Kingston, Ont	44	13	76	29	285
627	Montreal, Quebec	45	30	73	35	187
628	Ottawa, Ont	45	24	75	43	333
629	Killaloe, Ont	45	30	77	30	571
6/3	Traverse City, Mich	44	[1] 45	85	[1] 39	630
630	Muskoka, Ont	44	42	79	13	926
631	Parry Sound, Ont	45	19	80	00	635
632	Southhampton, Ont	44	30	81	21	656
633						
634	Harbor Beach, Mich	43	49	82	47	736
635	Grand Rapids, Mich	42	54	85	40	689
636	Muskegon, Mich	43	10	86	15	633
637						
638						
639	Alpena, Mich	45	04	83	30	609
640	Milwaukee, Wis	42	57	87	54	698
641	Madison, Wis	43	08	89	20	866
642	Charles City, Iowa	43	04	92	38	1, 015

[1] Approximate.

CODE TABLE 43.—*International index numbers for North America*—Continued

Index No.	Name of station	Latitude north Deg.	Latitude north Min.	Longitude west Deg.	Longitude west Min.	Altitude (Hb) Feet
643	La Crosse, Wis	43	56	91	17	672
644	Rochester, Minn	44	00	92	29	1, 021
645	Green Bay, Wis	44	31	88	00	617
646	Wausau, Wis	44	57	89	36	1, 196
647						
648	Escanaba, Mich	45	48	87	05	612
649						
650						
651	Sioux Falls, S. Dak	43	32	96	46	1, 427
652						
653	Springfield, Minn	44	14	94	57	1, 025
654	Huron, S. Dak	44	21	98	14	1, 289
655						
656	Watertown, S. Dak	44	55	97	07	1, 740
657	St. Paul, Minn	44	58	93	03	720
658	Minneapolis, Minn	44	53	93	13	720
659	Aberdeen, S. Dak	45	29	98	30	1, 300
660						
661	Newcastle, Wyo	43	52	104	12	4, 480
662	Rapid City, S. Dak	44	11	103	05	3, 218
663						
664	Pierre, S. Dak	44	22	100	12	1, 555
665						
666	Sheridan, Wyo	44	46	106	58	3, 968
667	Broadus, Mont	45	26	105	24	3, 032
668	Mobridge, S. Dak	45	31	100	25	1, 664
669	Lemmon, S. Dak	45	55	102	09	2, 602
670						
671	Idaho Falls, Idaho	43	31	112	04	4, 744
672						
673	Dubois, Idaho	44	10	112	18	5, 133
674	Cody, Wyo	44	32	109	04	4, 999
675	Yellowstone Park, Wyo	44	58	110	42	6, 241
676	West Yellowstone, Mont	44	39	111	06	6, 669
677	Billings, Mont	45	48	108	32	3, 570
678	Livingston, Mont	45	40	110	32	4, 618
679	Butte, Mont	45	58	112	30	5, 528
680						
681	Boise, Idaho	43	34	116	13	2, 858
682						
683	Burns, Oreg	43	30	119	08	4, 212
684						
685	Baker, Oreg	44	48	117	48	3, 373
686	Salmon, Idaho	45	11	113	53	3, 947
687	Grangeville, Idaho	45	56	116	08	3, 409
688	Pendleton, Oreg	45	41	118	51	1, 495

CODE TABLE 43.—*International index numbers for North America*—Continued

Index No.	Name of station	Latitude north Deg.	Latitude north Min.	Longitude west Deg.	Longitude west Min.	Altitude (Hb) Feet
689	Walla Walla, Wash	46	02	118	20	1,000
690	Roseburg, Oreg	43	13	123	20	508
691	North Bend, Oreg	43	23	124	13	207
692	Bend, Oreg	44	04	121	19	3,632
693	Eugene, Oreg	44	20	123	07	433
694						
695	Newport, Oreg	44	38	124	04	159
696	Timberline Lodge, Oreg	45	[1] 23	121	43	6,100
697	Northdalles, Oreg	45	[1] 35	121	[1] 08	
698	Portland, Oreg	45	36	122	36	39
699	Tongue Point, Oreg	46	[1] 12	123	57	
700						
701						
702						
703	Houlton, Me	46	07	67	48	476
704	Fredericton, New Brunswick	45	57	66	36	164
705	Moncton, New Brunswick	46	09	64	45	50
706	Challottetown, P. E. I	46	14	63	07	75
707	Sydney, Nova Scotia	46	09	60	12	119
708	St. Paul Island, N. S	47	12	60	13	104
709	Grindstone Island, Que	47	21	61	59	196
710						
711	Megantic, Que	45	33	70	50	1,314
712	Caribou, Me	46	53	67	58	628
713						
714	Quebec, Que	46	48	71	13	296
715	Kedgewick; New Brunswick	47	38	67	23	901
716						
717	Chatham, New Brunswick	47	03	65	29	98
718						
719	Father Point, Que	48	31	68	28	20
720						
721						
722						
723	Chalk River, Ont	46	00	77	26	550
724						
725						
726						
727	San Maur, Que	47	53	73	48	1,170
728	Senneterre, Que	48	24	77	15	
729	St. Felicien, Que	48	48	72	20	413
730						
731	North Bay, Ont	46	19	79	28	1,210
732						
733						

[1] Approximate.

Code Table 43.—*International index numbers for North America*—Continued

Index No.	Name of station	Latitude north Deg.	Latitude north Min.	Longitude west Deg.	Longitude west Min.	Altitude (Hb) Feet
734	Sault Ste. Marie, Mich	46	28	84	21	724
735	Earlton, Ont	47	41	79	51	805
736	Haileybury, Ont	47	29	79	39	707
737						
738	White River, Ont	48	35	85	16	1, 244
739	Porquis Junction, Ont	48	43	80	43	1, 009
740	Land O'Lakes, Wis	46	09	89	14	1, 710
741	Park Falls, Wis	45	56	90	27	1, 539
742	Hinckley, Minn	46	01	92	57	1, 054
743	Marquette, Mich	46	34	87	24	734
744	Houghton, Mich	47	07	88	34	668
745	Duluth, Minn	46	47	92	06	1, 133
746	Grand Marais, Minn	47	[1] 45	90	[1] 23	
747	International Falls, Minn	48	36	93	24	1, 126
748						
749	Port Arthur, Ont	48	27	89	12	644
750						
751	Alexandria, Minn	45	53	95	22	1, 431
752	Moorhead, Minn	46	52	96	44	940
753	Fargo, N. Dak	46	54	96	48	899
754	Jamestown, N. Dak	46	56	98	40	1, 494
755	Bemidji, Minn	47	29	94	54	1, 377
756	Grand Forks, N. Dak	47	56	97	05	832
757	Devil's Lake, N. Dak	48	07	98	52	1, 478
758	Pembina, N. Dak	48	55	97	16	803
759	Roseau, Minn	48	51	95	45	1, 053
760						
761	Miles City, Mont	46	26	105	52	2, 634
762	Glendive, Mont	47	06	104	42	2, 077
763	Dickinson, N. Dak	46	48	102	48	2, 583
764	Bismarck, N. Dak	46	47	100	48	1, 660
765	Garrison, N. Dak	47	38	101	25	1, 925
766	Minot, N. Dak	48	14	101	17	1, 574
767	Williston, N. Dak	48	09	103	35	1, 878
768	Glasgow, Mont	48	12	106	38	2, 086
769						
770						
771	Lewistown, Mont	47	03	109	27	4, 122
772	Helena, Mont	46	36	112	00	3, 898
773	Missoula, Mont	46	52	114	00	3, 189
774						
775	Great Falls, Mont	47	30	111	21	3, 657
776						
777	Havre, Mont	48	34	109	40	2, 507
778	Cut Bank, Mont	48	37	112	19	3, 762
779	Kalispell, Mont	48	10	114	25	2, 984

[1] Approximate.

Code Table 43.—*International index numbers for North America*—Continued

Index No.	Name of station	Latitude north Deg.	Latitude north Min.	Longitude west Deg.	Longitude west Min.	Altitude (Hb) Feet
780	La Crosse, Wash	46	49	117	53	1, 544
781	Yakima, Wash	46	36	120	30	1, 076
782	Ellensburg, Wash	47	02	120	31	1, 735
783	Wenatchee, Wash	47	25	120	21	1, 452
784	Mullen Pass, Idaho	47	27	115	41	6, 037
785	Spokane, Wash	47	40	117	20	1, 968
786	Bonner's Ferry, Idaho	48	42	116	18	1, 975
787	Colville, Wash	48	32	117	55	1, 862
788	Oroville, Wash	48	58	119	24	951
789						
790						
791	North Head, Wash	46	18	124	05	211
792	Olympia, Wash	46	58	122	53	200
793	Seattle, Wash	47	32	122	16	30
794	Moclips, Wash	47	14	124	12	63
795	Port Townsend, Wash	48	06	122	46	111
796						
797	Bellingham, Wash	48	45	122	29	103
798	Tatoosh Island, Wash	48	23	124	44	86
799	Victoria, B. C	48	40	123	26	
800	Cape Race, N. F	46	31	53	04	99
801	St. John's, N. F	47	34	52	42	243
802	Grand Bank, N. F	47	04	55	46	19
803	Newfoundland Airport, N. F	48	51	54	34	482
804	Millertown Junction, N. F	49	00	56	21	532
805	St. Georges, N. F	48	28	58	25	10
806	Fogo, N. F	49	43	54	17	25
807	Argentia Harbor, N. F	47	20	54	00	
808						
809	Belle Isle, N. F	51	53	55	22	426
810	Anticosti, S. W. Point, Que	49	24	63	33	30
811	Fame Point, Que	49	07	64	36	176
812	Clarke City, Que	50	12	66	38	186
813						
814	Harrington, Que	50	32	59	30	30
815						
816	Northwest River, Labr	53	34	60	06	45
817						
818	Cartwright, Labr	53	42	56	57	34
819						
820						
821	Lake Dore, Que	49	53	74	23	[1] 1, 234
822						
823						
824						
825						
826						

CODE TABLE 43.—*International index numbers for North America*—Continued

Index No.	Name of station	Latitude north Deg.	Latitude north Min.	Longitude west Deg.	Longitude west Min.	Altitude (Hb) Feet
827	Sandgirt Lake, Labr	54	00	65	30	1,650
828	Neoskweskan, Que	52	14	74	30	
829						
830	Cochrane, Ont	49	02	81	00	930
831	Kapuskasing, Ont	49	25	82	25	752
832						
833	Pagwa, Ont	50	00	85	20	620
834						
835						
836	Moosonee, Ont	51	13	80	31	29
837						
838						
839						
840	Nakima, Ont	50	15	86	30	
841	Armstrong, Ont	50	15	88	55	1,065
842	Sioux Lookout, Ont	50	08	91	52	1,227
843						
844						
845	Pickle Lake, Ont	51	28	90	18	1,254
846	Lansdowne House, Ont	52	21	88	03	
847						
848	Trout Lake, Ont	53	32	89	96	630
849						
850	Kenora, Ont	49	48	94	32	1,346
851						
852	Winnipeg, Man	49	53	97	07	760
853	Minnedosa, Man	50	15	99	50	1,690
854	Red Lake, Ont	51	02	93	50	1,255
855	Little Grand Rapids, Ont	51	35	95	15	
856						
857						
858	Norway House, Man	53	59	97	50	720
859	God's Lake, Man	54	50	94	50	[1] 610
860	Rivers, Man	50	00	100	15	1,553
861	Broadview, Sas	50	23	102	33	2,033
862	Qu'Appelle, Sas	50	31	103	56	2,147
863	Regina, Sas	50	27	104	37	1,884
864	Moose Jaw, Sas	50	21	105	35	1,860
865						
866	Saskatoon, Sas	52	08	106	38	1,690
867	The Pas, Man	53	49	101	15	890
868						
869	Prince Albert, Sas	53	10	105	45	1,432
870	Swift Current, Sas	50	20	107	45	2,677
871						
872	Medicine Hat, Alberta	50	01	110	37	2,365

[1] Approximate.

CODE TABLE 43.—*International index numbers for North America*—Continued

Index No.	Name of station	Latitude north Deg.	Latitude north Min.	Longitude west Deg.	Longitude west Min.	Altitude (Hb) Feet
873						
874	Lethbridge, Alb	49	43	112	51	3, 018
875	Cowley, Alb	49	30	114	00	3, 934
876	Battleford, Sas	52	41	108	20	1, 620
877	Calgary, Alb	51	02	114	02	3, 540
878	Penhold, Alb	52	08	113	50	
879	Edmonton, Alb	53	33	113	30	2, 219
880	Wasa, B. C	53	33	113	30	2, 219
881	Cranbrook, B. C	49	47	115	45	
882	Copper Mountain, B. C	49	30	115	47	3, 014
883						
884	Crescent Valley, B. C	49	25	117	30	
885	Carmi, B. C	49	30	119	05	4, 084
886	Princeton, B. C	49	26	120	30	2, 283
887	Kamloops, B. C	50	41	120	20	1, 262
888	Jasper, Alb	52	53	118	09	3, 480
889	Penticton, B. C	49	29	119	34	
890	Hope, B. C	49	18	121	30	126
891						
892	Vancouver, B. C	49	17	123	05	22
893	Bella Bella, B. C	52	09	128	05	
894	Estevan, B. C	49	22	126	32	20
895	Bull Harbor, B. C	50	55	127	57	15
896	Prince George, B. C	53	50	122	48	1, 870
897	Williams Lake, B. C	52	10	122	05	1, 945
898	Prince Rupert, B. C	54	18	130	18	170
899	Langara, B. C	54	15	133	06	134
900						
901	Ft. McKenzie, Que	56	00	67	00	
902						
903	Resolution, Hudson Strait	61	18	64	53	[1] 125
904	Hopes Advance, Hudson St	61	05	69	33	[1] 240
905	Great Whale River, Que	55	17	78	20	50
906						
907	Port Harrison, Que	58	25	78	21	12
908	Nottingham, Hudson St	63	07	77	56	[1] 54
909						
910						
911						
912						
913	Churchill, Man	58	47	94	11	43
914						
915						
916	Chesterfield, D. Keewatin	63	20	90	43	13
917						
918	Arctic Bay, D. of Franklin	73	00	84	30	

[1] Approximate.

CODE TABLE 43.—*International index numbers for North America*—Continued

Index No.	Name of station	Latitude north Deg.	Min.	Longitude west Deg.	Min.	Altitude (Hb) Feet
919	Ross, D. of Franklin	71	55	94	15	----
920	----	----		----		----
921	----	----		----		----
922	Lac LaRonge, Sas	55	15	105	30	----
923	----	----		----		----
924	----	----		----		----
925	Nueltin Lake, D. Keewatin	60	30	99	00	----
926	Baker Lake, N. W. T	64	24	97	07	----
927	----	----		----		----
928	----	----		----		----
929	----	----		----		----
930	----	----		----		----
931	----	----		----		----
932	McMurray, Alb	56	44	111	23	829
933	Keg River, Alb	57	49	117	53	1, 402
934	Smith, Alb	60	00	111	52	[1] 680
935	----	----		----		----
936	Yellow Knife, D. of Mack	62	30	114	05	----
937	----	----		----		----
938	Coppermine, D. of Mack	67	49	115	10	13
939	----	----		----		----
940	Grande Prairie, Alta	55	15	118	48	----
941	Beaver Lodge, Alta	55	10	119	19	2, 500
942	Fairview, Alta	56	04	118	23	2, 160
943	Fort St. John, B. C	56	18	120	48	----
944	Hudson Hope, B. C	56	05	121	55	1, 606
945	Nelson (Fort), B. C	58	49	122	35	970
946	Fort Simpson, D. of Mack	61	52	121	15	[1] 415
947	Fort Grahame, B. C	56	44	124	33	----
948	----	----		----		----
949	Holman Island, N. W. T	70	30	117	38	----
9/5	Cape Decision, Alaska	56	00	134	08	50
950	Smithers, B. C	54	46	127	10	14
951	Craig, Alaska	55	29	133	09	14
952	Ketchikan, Alaska	55	21	131	39	20
953	Watson Lake, B. C	59	55	128	45	1, 830
954	Atlin, B. C	59	35	133	38	2, 240
955	Haines, Alaska	49	13	135	26	269
956	Norman (Fort), D. of Mack	64	54	125	30	[1] 300
957	Frances Lake, B. C	61	20	129	15	----
958	Dease Lake, B. C	58	49	130	08	----
959	----	----		----		----
960	Petersburg, Alaska	56	49	132	57	111
9/6	Biorka, Alaska (Near Sitka)	56	51	135	[1] 32	216
961	Sitka, Alaska	57	03	135	20	23
962	Juneau, Alaska	58	18	134	24	80

[1] Approximate.

CODE TABLE 43.—*International index numbers for North America*—Continued

Index No.	Name of station	Latitude north Deg.	Latitude north Min.	Longitude west Deg.	Longitude west Min.	Altitude (Hb) Feet
963	Yakutat, Alaska	59	32	139	44	90
964	Whitehorse, Yukon	60	50	135	00	--------
965	Mayo, Yukon	63	35	135	51	1, 625
966	Dawson, Yukon	64	04	139	29	1, 062
967	Tanacross, Alaska	63	24	149	19	[1] 1, 200
968	Aklavik, D. of Mack	68	14	134	50	25
969	------	------		-------		--------
970	Kodiak, Alaska	57	48	152	24	152
971	Cordova, Alaska	60	32	145	42	43
972	Seward, Alaska	60	06	149	27	60
973	Anchorage, Alaska	61	13	149	52	132
974	Fairbanks, Alaska	64	51	147	43	454
975	Rapids, Alaska	63	32	145	51	2, 131
976	Tanana, Alaska	65	10	152	06	218
977	------	------		-------		--------
978	Fort Yukon, Alaska	66	34	145	18	417
979	Wiseman, Alaska	67	26	150	13	[1] 675
9/8	Unalakleet, Alaska	63	53	160	46	24
980	Sandpoint, Alaska	55	20	160	30	--------
981	Kanatak, Alaska	57	34	156	02	27
982	Naknek, Alaska	58	42	157	02	86
983	Akularak, Alaska	62	30	164	25	33
984	Bethel, Alaska	60	45	161	47	38
985	McGrath, Alaska	62	58	155	35	338
986	Ruby, Alaska	64	[1] 44	155	[1] 26	722
987	Nome, Alaska	64	30	165	24	22
988	Kotzebue, Alaska	66	52	162	38	16
989	Barrow, Alaska	71	23	156	17	25
990	Dutch Harbor, Alaska	53	53	166	32	13
991	Atka, Alaska	52	10	174	12	26
992	------	------		-------		--------
993	St. Paul, Alaska	57	15	170	10	20
994	Nunivak, Alaska	60	12	166	06	36
995	Gambell, Alaska	63	51	171	36	27
996	------	------		-------		--------
997	Attu, Alaska	52	56	173	13 E.	18
998	------	------		-------		--------
9/9	------	------		-------		--------
999	Honolulu, T. H	21	19	157	52	38
9/7	Copper Center, Alaska	61	58	145	19	[1] 1, 044
97/	Iliamna, Alaska	59	45	154	47	[1] 73
98/	Shungnak, Alaska	66	53	157	10	--------
/98	Point Hope, Alaska	68	20	166	44	18

[1] Approximate.

CODE TABLE 43.—*U. S. Coast Guard stations*

Index No.	Name of station	Latitude north Deg.	Latitude north Min.	Longitude west Deg.	Longitude west Min.	Altitude (Hb) Feet
30/	Elizabeth City, N. C.	36 [1]	19	76 [1]	14	------
31/	Oregon Inlet, N. C.	35	46	75	31	14
32/	Caffey's Inlet, N. C.	36	13	75	46	11
33/	Princess Anne, Va.	36	48	75	58	15
40/	Hog Island, Va.	37	26	75	43	15
41/	Assateague, Va.	37	55	75	22	19
42/	Ocean City, Md.	38	20	75	05	17
43/	Cape May, N. J.	38	55	74	55	14
44/	Barnegat, N. J.	39	46	74	06	15
45/	Ambrose Lightship, N. Y.	40	27	73	49	18
50/	Fire Island, L. I., N. Y.	40	37	73	14	19
51/	Tiana, L. I., N. Y.	40	50	72	35	16
52/	Ditch Plains, L. I., N. Y.	41	01	71	56	18

[1] Approximate.

CODE TABLE 44.—*Stations with International Index numbers having assigned verifying velocities*

Stations on Atlantic and Gulf coasts	Verifying velocity	Stations on Atlantic and Gulf coasts	Verifying velocity
Eastport	28	Wilmington	30
Portland	28	Charleston	30
Boston	28	Savannah	34
Nantucket	32	Jacksonville	32
Block Island	34	Miami	27
Providence	32	Key West	27
New Haven	24	Tampa	32
New York	36	Apalachicola	28
Sandy Hook	32	Pensacola	32
Atlantic City	32	Mobile	32
Delaware Breakwater	32	Port Eads	32
Baltimore	30	New Orleans	25
Norfolk	32	Port Arthur	27
Cape Henry	32	Galveston	26
Hatteras	32	Corpus Christi	33

DE TABLE 44.—*Stations with International Index numbers having assigned verifing velocities*—Continued

Stations on Great Lakes and Pacific Coast	Verifying velocity	Verifying velocity exceptions [1]
wego	26	
chester	22	27 sw. to w.
ıffalo	32	43 s. to w.
ie	29	36 se. to w.
eveland	36	30 n. to ne.
ndusky	25	
›ledo	28	32 sw. to nw.
etroit	28	32 sw. to nw.
pena	30	25 n. to ne.
hicago	30	25 n. to se.
ilwaukee	33	
reen Bay	30	
scanaba	26	30 n. to ne.
ıult Ste. Marie	24	32 nw.
[arquette	26	33 se. to sw.
uluth	32	25 e. to s.
PACIFIC COAST		
orth Head	38	46 se.
atoosh Island	40	47 se.
eattle	27	33 se. to sw.
ureka	26	32 nw.
an Francisco	25	32 sw. to nw.
›os Angeles	25	18 se. to sw.
an Diego	25	
an Pedro	36	30 ne. to se.

[1] Certain stations on the Great Lakes and Pacific Coast have higher or lower verifying velocities for ›ecified directions, as shown in list of exceptions.

CODE TABLE 45.—*Stations reporting 5,000-foot pressure*

Index number	Station	Index number	Station
560	Akron, Colo.	388	Independence, Calif.
365	Albuquerque, N. Mex.	589	Lakeview, Oreg.
262	Alpine, Tex.	463	Lamar, Colo.
363	Amarillo, Tex.	576	Lander, Wyo.
487	Austin, Nev.	771	Lewiston, Mont.
685	Baker, Oreg.	678	Livingston, Mont.
692	Bend, Oreg.	267	Lubbock, Tex.
577	Big Piney, Wyo.	475	Milford, Utah.
677	Billings, Mont.	773	Missoula, Mont.
579	Burley, Idaho.	473	Modena, Utah.
683	Burns, Oreg.	276	Mogollon, N. Mex.
679	Butte, Mont.	461	Monte Vista, Colo.
877	Calgary, Canada.[1]	490	Mt. Hamilton, Calif.
269	Carrizozo, N. Mex.	316	Mt. Mitchell, N. C.
569	Casper, Wyo.	595	Mt. Shasta, Calif.
568	Chadron, Nebr.	613	Mt. Washington, N. H.
564	Cheyenne, Wyo.	784	Mullan Pass, Idaho.
367	Clayton, N. Mex.	661	New Castle, Wyo.
674	Cody, Wyo.	565	Parco, Wyo.
571	Craig, Colo.	578	Pocatello, Idaho.
377	Crown Point, N. Mex.	372	Prescott, Ariz.
778	Cut Bank, Mont.	464	Pueblo, Colo.
479	Delta, Utah.	662	Rapid City, S. Dak.
469	Denver, Colo.	488	Reno, Nev.
673	Dubois, Idaho.	574	Rock Springs, Wyo.
570	Duchesne, Utah.	272	Rodeo, N. Mex.
471	Durango, Colo.	268	Roswell, N. Mex.
582	Elko, Nev.	686	Salmon, Idaho.
270	El Paso, Tex.	572	Salt Lake City, Utah.
486	Ely, Nev.	383	Sandberg, Calif.
275	Engle, N. Mex.	666	Sheridan, Wyo.
465	Goodland, Kans.	563	Sidney, Nebr.
378	Grand Canyon, Ariz.	584	Susanville, Calif.
476	Grand Junction, Colo.	485	Tonopah, Nev.
687	Grangeville, Idaho.	460	Trinidad, Colo.
775	Great Falls, Mont.	364	Tucumcari, N. Mex.
477	Green River, Utah.	581	Wendover, Utah.
484	Hawthorne, Nev.	583	Winnemucca, Nev.
772	Helena, Mont.	374	Winslow, Ariz.
580	Humboldt, Nev.	675	Yellowstone National Park, Wyo.
671	Idaho Falls, Idaho.		

[1] Station of the Canadian Meteorological Service.

Section V
WEATHER FORMS

68. General.—*a.* Accurate and systematic records are kept at all Army Air Forces weather stations in sufficient detail to permit the determination of the weather prevailing at any given time since the establishment of the station. In most cases, the forms on which the records are kept are Signal Corps forms although a number of commercial and revised forms have come into use. In the preparation of forms and records, the adherence to standard practice is a matter of primary importance. The value of weather data depends upon the use of standard equipment, the correct exposure of this equipment, and the strict compliance with standard practice in observing and reducing the data. The discussion and instructions contained in this section are in agreement with the dictates of standard practice and should be closely followed.

b. The following forms are maintained at each station:

(1) W. D., S. C. Form No. 1 (Monthly Record of Weather Observations).
(2) W. D., S. C. Form No. 2 (Daily Observations).
(3) W. D., S. C. Form No. 93 (Airway Weather Reports).
(4) W. D., S. C. Form No. 94 (Airway Weather Report).
(5) W. D., S. C. Form No. 97, 100 or 104.
(6) W. D., S. C. Form No. 98 or 111 (Barograph Record Sheet).
(7) W. D., S. C. Form No. 120-A.
(8) W. D., S. C. Form No. 130 (Hygrograph).
(9) W. D., S. C. Form No. 201 (Pilot Balloon Ascension Report).

The forms listed above, with the exception of Nos. 1, 94, and 201, will remain on file at the station for a period of 3 months, after which time

they may be destroyed. Form Nos. 1, 94, and 201 remain permanently on file. Form No. 93 is accomplished and kept on file for [illegible] months only by those stations *not* equipped with teletype facilities.

69. W. D., S. C. Form No. 1 (Monthly Record of Weather Observations).—*a. General.*—(1) Form No. 1 presents in concise form a summary of the weather conditions at the station in such manner that studies of climatic conditions essential to the planning of the allocation and employment of military equipment may be rapidly and accurately conducted. In general, the record contains those

(Form No. 1)

WAR DEPARTMENT
SIGNAL CORPS

ORIGINAL MONTHLY RECORD
OF
WEATHER OBSERVATIONS
AT

____

For the Month of ____________, 19__

Location of station, ____________________

Latitude, ...°........′; longitude, ...°........′; height of station barometer above sea level, ... feet; height above the ground of anemometer, ... feet; rain gage, ... feet; dry thermometer, ... feet.

*Station is supplied with a register ML–........, barograph ML–........, hygrograph ML–........, thermograph ML–........, sunshine recorder ML–........, and self-recording rain gage ML–........

Serial numbers of instruments in use during the month: Station barometer, ...; extra barometer, ...; anemometer, ...; dry thermometer, ...; wet thermometer, ...; maximum thermometer, ...; minimum thermometer, ... Anemometer was cleaned and oiled ....

Sum of corrections of station barometer, ... inches; of extra barometer, ... inches.

If any instrument has been moved during the month, give name of instrument, date, and details concerning the change, including change, if any, in height of barometer
____

* [illegible]

(1)

FIGURE 139.—Page 1, Form No. 1.

items that are of particular importance to aircraft and antiaircraft operation.

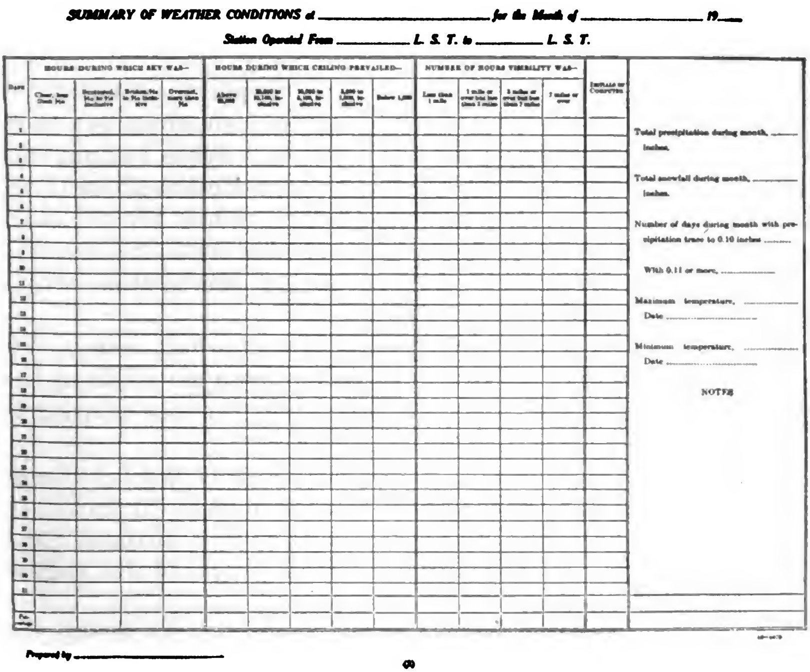
(2) One copy of Form No. 1 will be prepared at each station. All entries should be made in black record ink except when otherwise directed. If an error is made in an entry, a horizontal line will be drawn through it and the correct entry made above in black ink. Erroneous entries will *not* be erased. Explanatory notes should be made on the margins of all pages for any interpolated, missing or irregular entries. If space is not sufficient on the margin, full explanation should be made on page 4 under "Notes."

b. Page 1.—(1) Following "At" enter the name of the station and the month to which the ensuing records pertain.

(2) For "Location of station," name the building and part of the building in which the station is housed.

(3) Latitude and longitude of the station should be entered to the nearest minute.

(4) Record the height of the barometer above sea level and the height of instruments above the ground, to the nearest foot. The height of the ivory point of the barometer above sea level is considered as the height of the barometer.



SUMMARY OF WEATHER CONDITIONS at ____________ for the Month of ____________ 19__

Station Operated From ________ L. S. T. to ________ L. S. T.

HOURS DURING WHICH SKY WAS—

HOURS DURING WHICH CEILING PREVAILED—

NUMBER OF HOURS VISIBILITY WAS—

Total precipitation during month, ______ inches.

Total snowfall during month, ______ inches.

Number of days during month with precipitation trace to 0.10 inches ______

With 0.11 or more, ______

Maximum temperature, ______
Date ______

Minimum temperature, ______
Date ______

NOTES

Prepared by ____________

FIGURE 140.—Page 2, Form No. 1.

(5) Indicate the Signal Corps catalog number of each instrument used at the station, canceling words which are not appropriate.

(6) List the serial numbers of instruments in use during the month, and record the date on which the anemometer was last cleaned and oiled.

(7) The "Sum of corrections" consists of the sum of the instrumental and gravimetric corrections. This value is found on Form No. 79 in the barometer case.

(8) Report changes in the location of any permanently installed instruments.

c. Page 2.—Only "record" observations are considered in obtaining the summations for entry on page 2. The unmarked line next to bottom is to be used for the total of each of the several columns. The last line will show the percentage of the total observed hours in which each condition existed. This value is obtained by dividing each sum by the total hours observed and multiplying the quotient by 100. Entry should be made to the nearest percent.

(1) *Heading.*—The requirements for the heading are self-explanatory. Entries of inclusive times of station operation should be made on a 24-hour clock basis.

(2) *Hours during which sky was.*—The daily spaces within each column under this heading will have entered therein the total number of hourly observations at which the described condition prevailed. This may best be obtained from Form No. 94. When two layers of scattered clouds are observed, the sky will be considered as though only one layer of scattered clouds existed. When broken clouds are observed with higher or lower scattered cloudiness, the condition will be considered broken. Overcast in any combination will be regarded as overcast.

(3) *Hours during which ceiling prevailed.*—The data required for accomplishment of the columns under this heading are obtained from Form No. 94 as the total number of hourly observations showing the indicated ceilings.

(4) *Number of hours visibility was.*—Entries under this heading are accomplished in a manner similar to that described in (3) above.

(5) *Column to extreme right.*—The totals and extreme values required for entry in the column to the extreme right of this page are obtained from the Forms No. 94 for the month.

d. Page 3.—(1) *Heading.*—The requirements for the heading are self-explanatory. Entries of inclusive times of station operation should be made on a 24-hour clock basis.

(2) *Temperature.*—The values of the maximum, minimum and average temperatures are obtained from the reverse side of Form No. 94 under "The day." Entry should be made to the nearest whole degree. The mean maximum, mean minimum and mean average temperatures are obtained and entered to the nearest whole degree.

(3) *Precipitation.*—(*a*) *Prevailing character.*—This entry is obtained from Form No. 94 under "The day." The mean prevailing character is that prevailing character which represents the greatest number of days. In that circumstance wherein two prevailing characters of precipitation occur on an equal number of days, both will be entered.

(*b*) *Total.*—The total precipitation to the nearest hundredth of an inch will be entered. This value is obtained from Form No. 94 under "The day."

(*c*) *Total snow on ground at 0800 LST.*—This value to the nearest tenth of an inch is obtained and transcribed from Form No. 94 under "The day."

(4) *Wind.*—(*a*) *Prevailing direction.*—The prevailing wind direction is obtained from Form No. 94 under "The day." The most frequently observed daily prevailing wind direction will be entered as

SUMMARY OF WEATHER CONDITIONS at .... for the Month of .... 19....

Station Operated From .... L. S. T. to .... L. S. T.

Date	Temperature: Maximum	Minimum	Average	Precipitation: Prevailing character	Total (inches)	Total snow on ground at 0800 L. S. T. (inches)	Wind: Prevailing direction	Average speed (m. p. h.)	Extreme speed	Direction of extreme speed	Hours wind 10 m. p. h. or less	Hours wind 11 to 20 m. p. h.	Hours wind over 20 m. p. h.	Fog: Hours light	Hours moderate	Hours thick	Hours dense	Initials of recorder	Date
1																			1
2																			2
3																			3
4																			4
5																			5
6																			6
7																			7
8																			8
9																			9
10																			10
11																			11
12																			12
13																			13
14																			14
15																			15
16																			16
17																			17
18																			18
19																			19
20																			20
21																			21
22																			22
23																			23
24																			24
25																			25
26																			26
27																			27
28																			28
29																			29
30																			30
31																			31
Sums				(a)			(a)		(a)	(a)									Sums
[illegible]					(a)	(a)	(b)		(c)	(d)	(e)	(e)	(e)	(e)	(e)	(e)	(e)		[illegible]

Temperature in degrees F.
Rain in inches and hundredths.
Snow in inches and tenths.

(a) No data required. (b) Most frequent kind, direction, or predominant character. (c) Extreme speed for the month. (d) Direction of extreme speed. (e) Percentage.

Prepared by ....

(3)

FIGURE 141.—Page 3, Form No. 1.

the mean prevailing wind. In the event that two prevailing wind directions occur a like number of times, both will be entered. Directions will be indicated by using literal abbreviations for the 16 points of the compass.

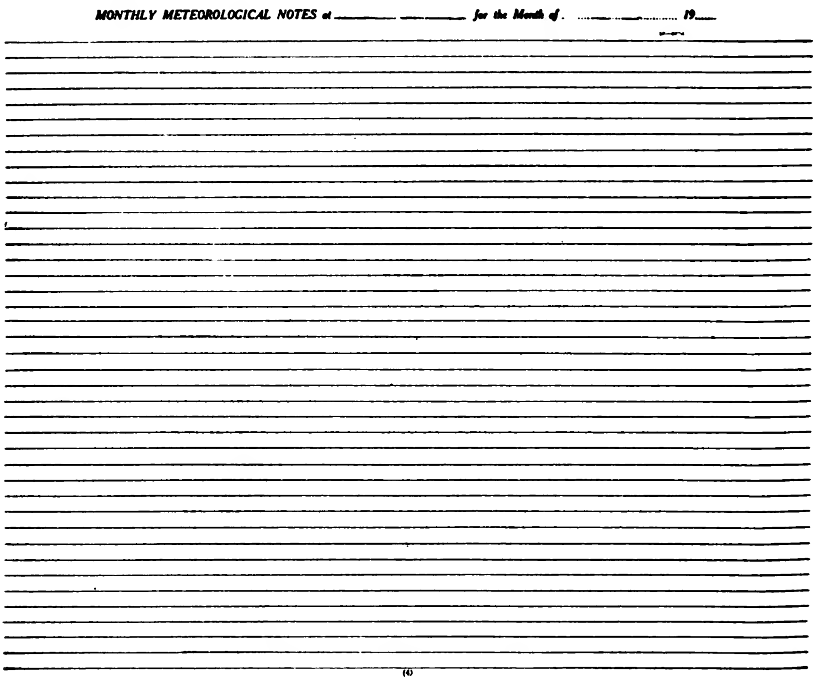
(*b*) *Average speed.*—This entry is transcribed from Form No. 94. The mean average speed is the sum of the average speeds divided by the number of days observed. Entry of this value is accomplished to the nearest mile per hour.

(*c*) *Extreme speed.*—The extreme wind speed will be obtained from

the wind register sheet, when available. If a wind register is not in operation, the highest observed value of the wind speed for all record, check, special and local extra observations will be entered as the extreme wind speed.

(*d*) *Direction of extreme speed.*—This direction is entered by employing literal designation of the semicardinal compass points.

(*e*) *Wind speed by hours.*—Data for the columns "Hours wind 10 mph or less," "Hours wind 11 to 30 mph," and "Hours wind over 30 mph," are obtained by determining the total number of hours of the


MONTHLY METEOROLOGICAL NOTES at ____________ for the Month of ____________ 19__

(4)

FIGURE 142.—Page 4, Form No. 1.

day represented by each range. Form No. 94 furnishes the most accessible means by which this may be done. The percentage of occurrence should be entered to the nearest whole percent.

(5) *Fog.*—Entries for each of the four intensities of fog are obtained from Form No. 94 under "The day."

(6) *Initials of recorder.*—These initials are those of the individual making the transcriptions and computations for the day.

e. Page 4.—On page 4 enter accounts of important weather phenomena, such as the intensity, time of beginning and ending of thunder-

storms and other climatic data not easily susceptible of tabulation, occurring at or in the vicinity of the station. In the reporting of weather phenomena, too much care cannot be exercised to make the account explicit and to state accurately the time of occurrence. Very often the omission of a single detail detracts materially from the value of the report. In describing weather phenomena, 2400 LST will be understood to refer to the end of the day and will receive the date thereof. Night will be referred to as "night of 3d-4th," and will cover the time from sunset to sunrise.

70. W. D., S. C. Form No. 2 (Daily Observations).—*a.* (1) Form No. 2 is a form originally designed for recording all of the elements of a "complete" surface observation. Formerly only one (or at most two) such observation was taken each day at a given station. All other observations were of the then-designated "short airways" type, involving only the ceiling, state of sky and/or weather, visibility, and wind speed. This circumstance prevailed, of course, before the advent of 24-hour station operation, hourly "complete" observations, extensive teletype communication and the like. As a result, the original utility of Form No. 2 as an item of record has been largely usurped by the development of Form No. 94 and kindred forms whose function is the preservation of data forming the bases of the messages entered in the hourly teletype sequence collections. Form No. 2 continues, however, to furnish a semipermanent record of certain data additional to that required for the teletype message, such as thermograph, hygrograph and barograph readings, which permit proper correction and maintenance of the recording instruments and registering instruments. For this indicated purpose, Form No. 2 will be used to record that surface observation whose time most nearly agrees with 0800 LST. In general, this form need not be employed for other observations during the day except as may be prescribed by local requirements or other competent authority.

(2) Due to the relatively recent development and extension of the requirements of a "complete" surface observation, a number of locally designed Forms No. 2 have come into use. These forms intended to provide appropriate spaces for entry of elements of data not formerly required. One such form is delineated in some detail in paragraph 71.

b. The individual entries in the standard Form No. 2 are described below. These are considered in the order in which they occur on the form and not in the order in which the several elements are properly observed.

c. Complete designation of the station and date constitutes the heading proper of Form No. 2. The entries pertaining to the character of sunrise and sunset, not now normally accomplished, originally intended to depict the state of cloudiness of the sky in that region wherein the sun made its first and last appearances. Symbolic

Form No. 2
Revised March 16, 1936

WAR DEPARTMENT
SIGNAL CORPS, U. S. ARMY
METEOROLOGICAL SERVICE

DAILY OBSERVATIONS

Station, ...

Date, ..., *19*.......

Character of sunrise ....: sunset	7:40 A. M. L. S. T.		
Barometer—			
Attached thermometer			
Observed reading			
Total correction			
Station pressure			
Reduced pressure			
Dry thermometer			
Wet thermometer			
Dew point			
Relative humidity			
Vapor pressure			
Maximum thermometer			
Minimum thermometer			
Direction and speed of wind			
Ceiling			
Visibility			
Precipitation			
Clouds — Upper			
Clouds — Lower			
Thermograph reading			
Hygrograph reading			
Barograph reading			

Compared with Form No. 1.

....

3—5761 (Use other side for notes)

FIGURE 143.—Form No. 2.

representation of this condition was then made but as stated above, this entry is no longer made.

(1) *Attached thermometer.*—The reading of the thermometer attached to the barometer tube is here recorded to the nearest half degree.

(2) *Observed reading.*—This entry refers to the reading of the barometer scale before any corrections have been made, and is recorded the nearest thousandth of an inch.

(3) *Total correction.*—The total correction represents the algebraic sum of the gravimetric, instrumental, and temperature corrections. This value is entered to the nearest thousandth of an inch.

(4) *Station pressure.*—This is obtained as the algebraic sum of (2) and (3) above, and is recorded to the nearest thousandth of an inch.

(5) *Reduced pressure.*—This is the sea-level pressure and is obtained to the nearest hundredth of an inch.

(6) *Dry thermometer.*—Herein record the current dry-bulb temperature, accurate to the nearest tenth of a degree. In addition, the temperature 12 hours ago should be entered in parentheses. This value is obtained to the nearest tenth of a degree. It may be obtained from the appropriate hourly observation record, or from the corrected thermograph trace, depending upon the availability of the former.

(7) *Wet thermometer.*—This entry refers to the temperature of the wet-bulb thermometer and should be accomplished to the nearest tenth of a degree.

(8) *Dew point.*—This, of course, is a derived quantity and is recorded to the nearest whole degree.

(9) *Relative humidity.*—Another derived quantity, entered to the nearest whole percent.

(10) *Vapor pressure.*—This quantity is obtained by reference to the psychrometric tables and is recorded here to the nearest thousandth of an inch.

(11) *Maximum thermometer.*—This refers to the reading of the maximum thermometer. Entry is obtained and entered *only* for the observation nearest 0800 LST. The reading is made to the nearest tenth of a degree.

(12) *Minimum thermometer.*—Enter here the reading of the minimum thermometer to the nearest tenth of a degree. Like the maximum temperature, this value is recorded *only* for that observation nearest 0800 LST.

(13) *Direction and speed of wind.*—The wind direction, accurate to 16 points of the compass, will be entered with literal abbreviations. The speed should be entered to the nearest mile per hour.

(14) *Ceiling.*—The ceiling is entered in hundreds of feet up to 20,000 feet. For ceilings over 20,000 feet, no entry is made.

(15) *Visibility.*—Recorded here in miles and fractions of miles.

(16) *Precipitation.*—Precipitation is measured and recorded only during the observation nearest 0800 LST, under normal circumstances. However, observation may be made and recorded at any time when probable loss thru evaporation or overflow justifies such departure. In any event the amount is recorded to the nearest hundredth of an inch.

(17) *Clouds.*—(*a*) *Upper.*—List herein the amount, kind and direction of any high and/or middle type clouds which may be present. The amount represents the number of tenths of the layer in question visible to the observer. The kind should be entered as a literal abbreviation; and the direction should be represented by literal designation of the semicardinal compass point from which the cloud is moving; for example, 8CS–SW.

(*b*) *Lower.*—In a manner similar to that described in (*a*) above, indicate any lower cloud types which may be present.

(18) *Thermograph reading.*—The current reading of the thermograph is obtained and recorded only for the observation nearest 0800 LST. The thermograph reading is entered to the nearest tenth of a degree.

(19) *Hygrograph reading.*—Like the thermograph reading, the reading of the hygrograph is obtained only once each day, that being for the observation nearest 0800 LST. Entry is made to the nearest percent.

(20) *Barograph reading.*—The barograph reading to the nearest hundredth of an inch is recorded once each day, that being for the observation nearest 0800 LST.

(21) *Notes.*—Any additional data, not provided for above, such as symbolic representation of the state of sky, weather, wind shifts, precipitation phenomena and the like will be entered in the available space at the bottom of Form No. 2 and, where this proves inadequate, on the reverse side.

71. W. D., S. C. Form No. 2 (modified).—*a.* The modified type of Form No. 2 contains the same information as Form No. 2 plus some additional data which are of use in filing weather information and in composing teletype reports. The entries are arranged in the general order in which they are obtained.

b. Before the observation is made, enter in the space reserved for "Station" the station, state, and in the space reserved for "Date," enter the month, day and year. The individual descriptions of the entries are found below.

(1) *Time.*—The time is the filing time of the report and is given on the 24-hour clock system in local standard time.

AIR CORPS, U. S. ARMY
WEATHER SERVICE

SURFACE OBSERVATIONS

Station:
Date:

1. Time				
2. Clouds ($C_l C_m C_h$)				
3. High				
4. Middle				
5. Low				
6. Ceiling				
7. Visibility				
8. Minimum Temperature				
9. Maximum Temperature				
10. Temperature Thermograph Rdg				
11. Wet-bulb Temperature				
12. Dew Point				
13. Relative Humidity Hygrograph Rdg.				
14. Amount of Precipitation				
15. Depth of Snow				
16. Weather				
17. Wind				
BAROMETER				
18. Attached Thermometer				
19. Observed Reading				
20. Total Correction				
21. Station Pressure Barograph Rdg.				
22. Temperature 12 Hrs. Ago				
23. Sea Level Pressure (in.)				
24. Sea Level Pressure (mb)				
25. Pressure Change				
26. Altimeter Setting				
27. Initials of Observer				

OVER

FIGURE 144.—Front page of modified type of Form No. 2.

(2) *Clouds* (C_L C_M C_H).—The entry here consists of the international code figures for low, middle, and high clouds. If there is no cloud at a level, enter zero.

(3) *High.*—List the amount, kind, and direction of any high clouds present. The amount represents the number of tenths of the layer in question visible to the observer. The kind should be entered as a standard literal abbreviation; and the direction should be represented by literal designation to eight points of the compass showing the direction from which the cloud is moving; for example, 3 CS–W. If there are no high clouds observed, enter O.

(4) *Middle.*—Indicate middle clouds in a manner similar to that prescribed for high clouds.

(5) *Low.*—Indicate low clouds in a manner similar to that prescribed for high clouds.

(6) *Ceiling.*—If there is a ceiling at or below 20,000 feet, a ceiling value is entered; if not, no entry is made. The value given will be the height of the ceiling in hundreds of feet; for example, a ceiling of 2,300 feet is reported 23. The height reported will be to the nearest 100 feet below 5,000 feet and to the nearest 500 feet above 5,000 feet. If the ceiling value is estimated, place the letter E before the height given.

(7) *Visibility.*—Enter the visibility value in miles and fractions of miles.

(8) *Minimum temperature.*—Enter the minimum thermometer reading to the nearest tenth of a degree. This reading is obtained and entered only for the observation nearest to 0800 LST.

(9) *Maximum temperature.*—Enter here the reading of the maximum thermometer to the nearest tenth of a degree. Like the minimum temperature, this value is recorded only for the observation nearest to 0800 LST.

(10) *Line 10.*—(*a*) *Temperature.*—The current dry-bulb thermometer reading is recorded to the nearest tenth of a degree.

(*b*) *Thermograph reading.*—The current thermograph reading is obtained and recorded in the space provided in the upper right-hand corner of line 10. This reading is recorded to the nearest tenth of a degree, and is obtained only during the observation nearest 0800 LST.

(11) *Wet-bulb temperature.*—The wet-bulb temperature is recorded to the nearest tenth of a degree.

(12) *Dew point.*—This is, of course, a derived quantity and is recorded to the nearest whole degree.

(13) *Line 13.*—(*a*) *Relative humidity.*—Relative humidity is another derived value and is recorded to the nearest whole percent.

(*b*) *Hygrograph reading.*—The hygrograph reading is recorded to the nearest whole percent in the space provided in the upper right-hand corner above the relative humidity value. Like the thermograph, this reading is taken only during the observation nearest to 0800 LST.

(14) *Amount of precipitation.*—The amount of precipitation is recorded in inches and hundredths of an inch. The observation will be made for the report nearest to 0800 LST, under normal circumstances. However, an observation may be made and recorded at any time when probable loss, due to overflow or evaporation, justifies such departure. If a trace of precipitation has fallen, record the letter T, and if none has fallen, record 0.00.

(15) *Depth of snow.*—The depth of snow is recorded to the nearest tenth of an inch and is obtained only during the observation nearest to 0800 LST. If a trace of snow is observed, record a letter T, and if none is observed, record 0.0.

(16) *Weather.*—Record all active weather elements occurring at time of observation in this space. Use the accepted standard literal weather symbols. After the symbols, indicate the intensity of the phenomena. If no active weather element is occurring, record the teletype sky coverage symbol indicating the maximum sky coverage present. If the sky is clear, enter the clear symbol.

(17) *Wind.*—The wind direction, accurate to 16 points of the compass, will be entered with literal abbreviation followed by the wind speed which is entered to the nearest mile per hour. If gustiness is present, indicate the degree of gustiness after the wind speed with the appropriate plus or minus sign.

(18) *Attached thermometer reading.*—The reading of the thermometer attached to the barometer tube is recorded here to the nearest half degree.

(19) *Observed reading.*—Record the barometer reading to the nearest thousandth of an inch as obtained from the barometer scale and before any corrections have been applied.

(20) *Line 20.*—(*a*) *Total correction.*—The total correction represents the algebraic sum of the gravimetric, instrumental and temperature corrections. This value is entered to the nearest thousandth of an inch. Indicate wherether the quantity is plus or minus by placing the appropriate symbol before the entry.

(*b*) *Sum of corrections.*—The sum of gravimetric and instrumental corrections is obtained from Form No. 79 in the barometer case and is entered in the space between the words "Total correction" and the

space used for entering the total correction. Indicate whether the quantity is plus or minus by placing the appropriate symbol before the entry.

(21) *Line 21.*—(*a*) *Station pressure.*—Station pressure is the algebraic sum of the observed reading and total correction and is recorded to the nearest thousandth of an inch.

(*b*) *Barograph reading.*—The barograph reading is reported to the nearest hundredth of an inch in the upper right-hand corner above the station pressure. When the value is entered, the whole inches of pressure are omitted and only the decimal point followed by tenths and hundredths digits are entered. The reading is recorded only once each day during the observation nearest to 0800 LST.

(22) *Temperature 12 hours ago.*—This value is entered to nearest tenth of a degree and may be obtained from the appropriate hourly observation record, or from the *corrected* thermograph trace, depending upon the availability of the former.

(23) *Sea-level pressure* (*inches*).—The sea-level pressure is obtained from the station pressure and is recorded to the nearest hundredth of an inch.

(24) *Sea-level pressure* (*millibars*).—The sea-level pressure in millibars is obtained by converting the sea-level pressure in inches to millibars by the use of code table No. 35 of the international weather code.

(25) *Line 25.*—(*a*) *Pressure change.*—The pressure change is obtained from the microbarograph trace for the last 3 hours preceding the observation, and is recorded to the nearest 0.005 inch.

(*b*) *Pressure change characteristic.*—The pressure change characteristic is obtained by inspection of the microbarograph trace and is entered by symbol, preceding the amount of change as one of the 10 recognized types of pressure change characteristics.

(26) *Altimeter setting.*—The altimeter setting is obtained from the station pressure by the use of the altimeter setting tables available for each station. It is recorded to the nearest hundredth of an inch pressure.

(27) *Initials of observer.*—The initials of the observer are entered in the space provided.

(28) *Date.*—The month, day, and year are entered in the space provided.

(29) *Remarks.*—In the section headed "Remarks," enter any remarks made during the observation, which would be entered on Form No. 94 or in the teletype message. Also, include the height of the lower scattered clouds in this space. The time at which the remarks

Date ____________________

Remarks (as entered on Form No. 94 and in teletype message and to include height of scattered clouds.)

____ ____.S.T.:

____ ____.S.T.:

____ ____.S.T.:

____ ____.S.T.:

METEOROLOGICAL PHENOMENA

Character and Intensity	Began	Ended	Remarks

FIGURE 145.—Back of modified type of Form No. 2.

are made is recorded along the short line to the left of the form. The entry is made on the 24-hour clock system and is followed by the letter designating the time belt used.

(30) *Meteorological phenomena.*—In the section headed "Meteorological phenomena" are entered all the active weather elements observed, as well as their intensity, time of ending and beginning, and remarks.

(*a*) *Character and intensity.*—In the column headed "Character and intensity", enter the accepted literal designators of active weather elements followed by the intensity of the phenomena.

(*b*) *Began.*—In the column headed "Began," enter the times on the 24-hour clock system at which the phenomena began.

(*c*) *Ended.*—In the column headed "Ended," enter the times on the 24-hour clock system at which the phenomena ended.

(*d*) *Remarks.*—In the column headed "Remarks," record any information pertinent to the weather element reported.

72. W. D., S. C. Form No. 93 (Airway Weather Reports).—*a. General.*—Form No. 93 is the form upon which stations not equipped with teletype service copy radio weather reports transmitted by voice.

b. Method of preparation.—In the following paragraph are the rules governing the entries made on Form No. 93.

(1) *Received at.*—In this space record the station and state.

(2) *Date.*—In this space record the month, the day, and the year.

(3) *Station.*—Herein record the call letters of the station sending the report.

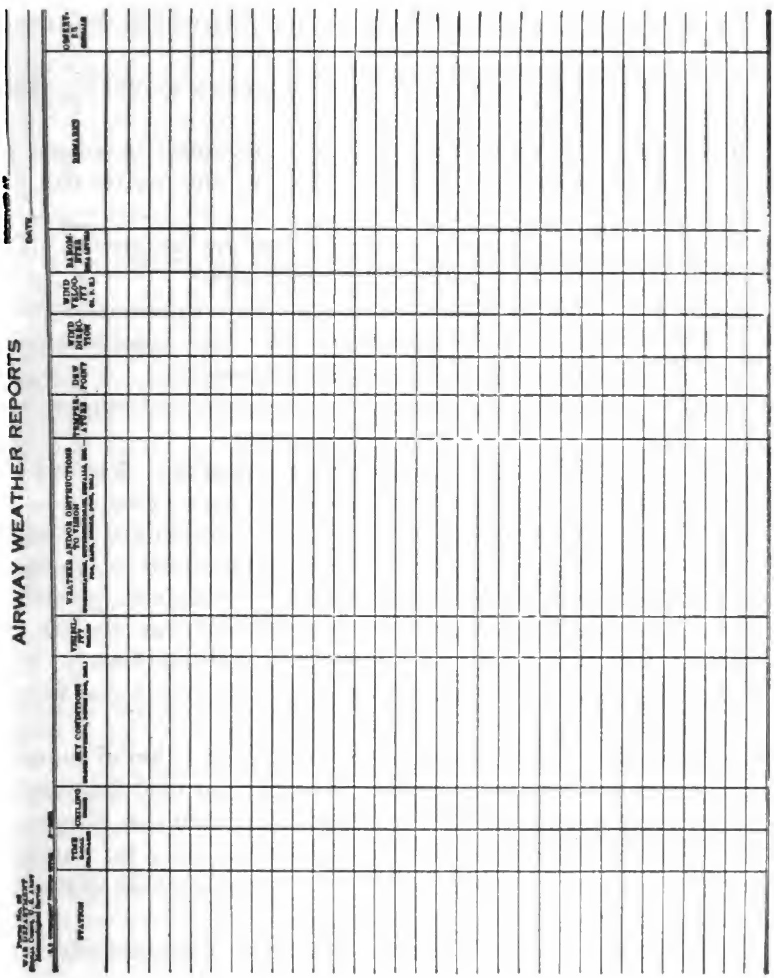
(4) *Time.*—Record the local standard time on the 24-hour clock system.

(5) *Ceiling.*—Record in hundreds of feet the ceiling value reported. Record E before the numerical value if the ceiling height has been estimated.

(6) *Sky conditions.*—In the column headed "Sky conditions," record the sky condition. Employ teletype sky symbols to indicate the amounts of coverage. In the event the sky is obscured, leave the space blank; if clear, enter the clear symbol. Active weather elements are recorded in the column headed "Weather and/or obstruction to visibility."

(7) *Visibility.*—Record the visibility values given in miles and fractions thereof.

(8) *Weather and/or obstructions to vision.*—In the column provided, record all the elements reported in the order given. Employ the literal teletype abbreviations in designating the types of phenomena.



AIRWAY WEATHER REPORTS

STATION	TIME	CEILING	SKY CONDITIONS	VISIBILITY	WEATHER AND/OR OBSTRUCTIONS TO VISION	TEMPERATURE	DEW POINT	WIND DIRECTION	WIND VELOCITY	BAROMETER	REMARKS	OBSERVER'S INITIALS

FIGURE 146.—Form No. 93.

After the type, indicate the intensity of the element by the use of a plus sign for heavy intensity, a minus sign for light, and enter no sign to indicate moderate intensity. If no active weather element is reported, leave the space blank.

(9) *Temperature.*—Record the temperature as received in whole degrees.

(10) *Dew point.*—Record the dew point as received in whole degrees.

(11) *Wind direction.*—Record the wind direction given by using literal abbreviations.

(12) *Wind velocity.*—The wind velocity is recorded in miles per hour. If gustiness occurs, indicate its degree by the use of the plus or minus signs.

(13) *Barometer.*—Record the barometer reading as given. This value represents the sea level pressure in millibars.

(14) *Remarks.*—Under "Remarks," enter any information contained in the remarks of the broadcast report. Use approved word abbreviations and teletype symbols whenever possible.

(15) *Observer's initials.*—The observer recording the report will initial the report upon completion of transmission.

73. W. D., S. C. Form No. 94 (Airway Weather Report).—*a. General.*—(1) Form No. 94 serves a dual purpose. First, it is the form on which are copied airway weather reports which are prepared for transmission by teletype or other means of communication. Second, the hourly teletype weather reports recorded on the form present a record of the daily weather at the station. All Forms No. 94 are filed and sent with the monthly records to the checking agency, and, after their return, are permanently preserved at all Army Air Forces weather stations.

(2) Due to relatively recent development and extension of requirements for weather information desired, several local modifications of Form No. 94 have come into use. These forms intend to dispose of entries no longer desired and provide appropriate space for entry of elements now required. The method of entry of one of these types will be discussed in a succeeding paragraph.

(3) The entries on Form No. 94 are made with a moderately hard pencil. They are put in chronological order with the data in proper columns or indicated by the headings. The form is not taken outside during the observation, but pertinent data of the observation are transferred to Form No. 94, as soon as practicable. Duplicate entries will be accomplished in full; ditto marks will not be used.

Form No. 94
WAR DEPARTMENT
Signal Corps, U. S. Army
Revised June 14, 19[illegible]

AIRWAY WEATHER REPORT

STATION ____________

DATE ____________

TIME ([illegible])	SKY (CODE)	CLASSIFI-CATION	CEILING (FEET)	SKY CONDITIONS	VISIBILITY (MILES)	WEATHER AND/OR OBSTRUCTIONS TO VISION	SEA LEVEL PRESSURE (MILLIBARS)	TEMPERA-TURE AND DEW POINT	WIND DIRECTION	WIND SPEED	WIND CHARACTER, SHIFTS	ALTIMETER SETTING (INCHES)	REMARKS	OBSERVER'S INITIALS

FIGURE 147.—Front page, Form No. 94.

b. *Front page*.—On the front page of Form No. 94 are recorded the elements which apply to the teletype weather reports.

(1) *Station*.—In the space reserved for "Station," record the complete designation of the station location, as Chanute Field, Illinois.

(2) *Date*.—Record here the month, day and the year.

(3) *Type*.—The type of report is entered in the left margin of Form No. 94 using the following designations: R for a record observation, S for a special observation, R/ S for record-special observations, and a check mark (✓) for a check observation.

(4) *Time*.—In the column headed "Time," record the time of the report using the 24-hour clock system. The proper letter is entered in the parenthesis below the word Time to indicate the local time zone.

(5) *Sky*.—This item is no longer accomplished. This column permitted entry of the code figure representing the state of the sky. The code employed was that element of the numerical code for land station reports which designates the state of the sky.

(6) *Classification*.—The space designated "Classification" provides for the classification of the weather described as C, N or X, as the case may be. In general, Army Air Forces weather stations do not classify their reports unless competently instructed to do so. When entry is accomplished in obedience to specific instruction, employment is made of the three literal designations mentioned above.

(7) *Ceiling*.—The ceiling value is entered in hundreds of feet for all values up to and including 20,000 feet. The value is given to the nearest 100 feet below 5,000 feet and to the nearest 500 feet above 5,000 feet. If no ceiling is reported, or if the value is above 20,000 feet, no entry is made. Place the letter E before estimated ceiling values and the letter V after the figures representing the ceiling if the condition described is variable.

(8) *Sky condition*.—Sky condition refers to the coverage of clouds as is indicated in the teletype weather message. The recognized teletype symbols are used for indicating sky coverage. A maximum of two sky symbols is allowable. The height of the lower scattered clouds is indicated in hundreds of feet. If the sky is obscured, the space is left blank, and if clear, use the clear symbol. A plus (+) sign preceding the cloudiness symbol indicates dark, and a minus (−) sign indicates thin coverage.

(9) *Visibility*.—The visibility values are reported in miles and fractions thereof. The values which may be used are: 0, $\frac{1}{8}$, $\frac{1}{8}$, $\frac{1}{4}$, $\frac{1}{2}$, $\frac{3}{4}$, 1, $1\frac{1}{4}$, $1\frac{1}{2}$, $1\frac{3}{4}$, 2, $2\frac{1}{4}$, $2\frac{1}{2}$, 3, 4, 5, 6, 7, 8, and 9. For any visibility

values less than 7 miles, the restriction must be explained by some weather or obstruction to visibility element or elements. The absence of a visibility value indicates that the visibility is 10 miles or more. Variable visibility is indicated by a letter V following the visibility value.

(10) *Weather and/or obstruction to visibility.*—Herein record the active weather elements as they are given in a teletype report. Use the recognized literal weather element abbreviations. If no active weather element is occurring, leave the space blank.

(11) *Sea-level pressure.*—Record the sea-level pressure in millibars and tenths of millibars.

(12) *Temperature and dew point.*—Record the temperature in whole degrees followed by a slant line and the dew point in whole degrees.

(13) *Wind direction.*—Enter the wind direction to 16 points of the compass using literal abbreviations; for example, NNE. If a calm exists, record the letter C.

(14) *Wind speed.*—The wind speed is entered in miles per hour. Character of gustiness, when appropriate, is entered immediately following the wind velocity, by use of the minus sign (—) to indicate fresh and the plus sign (+) to indicate strong gusts. If the velocity is estimated, place the letter E after the velocity.

(15) *Wind character, shifts.*—In this column record all wind shifts First, give the direction of the wind before the shift to eight points of the compass by use of short arrows. Then give the time on the 24-hour clock system followed by the appropriate letter to denote the time zone. After that indicate the intensity of the shift by the use of a plus sign (+) for severe, minus sign (—) for mild, and moderate intensity by the absence of a sign.

(16) *Altimeter setting.*—Record the altimeter setting to the nearest hundredth of an inch.

(17) *Remarks.*—In the "Remarks" column record all pertinent weather information which cannot properly be described by recording the items preceding it on the form. Some stations which are designated to send out additional data groups at certain times will insert the data in the "Remarks" column. A cloud report for each observation is entered to the right of the "Remarks" column following the remarks pertaining to the teletype report and the additional data groups. It is made up as follows: First, give by numerical designators the tenths covered, then give the type followed by a dash and the direction from which the clouds are moving. The type and direction

are given in the abbreviated literal forms. List all the layers placing the higher cloud types above, for example:

REMARKS

FOG BNK S/507	55062	6 Ac–SE 2 Cu–E

(18) *Observer's initials.*—The observer will record his initials after each observation.

c. *Reverse side.*—The reverse side of Form No. 94 is used to record the character and duration of all active weather elements occurring during the day, and also, to summarize the weather for each day from midnight to midnight.

(1) *Precipitation, and haze, smoke, dust, and fog.*—Under the column headed, "Precipitation", record all the weather elements which are active precipitation. In the column headed, "Haze, smoke, dust, and fog", record these four elements causing limitation of visibility. The rules governing the entries for character, intensity, beginning, and ending, are identical and are discussed in the following paragraphs.

(*a*) *Character.*—The characters of the phenomena are entered in chronological order in this column. The entries are made in the recognized literal teletype abbreviations.

(*b*) *Intensity.*—The intensity of each phenomenon is indicated by recording a minus sign (—) for light, a plus sign (+) for heavy intensity. Moderate intensity is indicated by the lack of a symbol.

(*c*) *Beginning.*—Record the time the phenomenon began, using the 24-hour clock system. If the station does not operate on a 24-hour basis, and the time is therefore unknown, record DNA for "during night, a. m.," or after midnight, and DNP for "during night, p. m.," or before midnight. If the precipitation continued from the previous day, record three dashes (– – –).

(*d*) *Ending.*—Record the time the phenomenon ended, using the 24-hour clock system. If the station does not operate 24 hours each day, and the exact ending time is unknown, record DNA for "during night, a. m.," or after midnight. DNP is used for "during night, p. m.," or before midnight. In the event that the precipitation continues beyond midnight, indicate by recording three dashes (– – –).

(2) *Thunderstorms.*—All thunderstorms are recorded in this column.

(*a*) *Intensity.*—Thunderstorms may be of two intensities, "heavy thunderstorm" or "thunderstorm." If the thunderstorm is heavy, record a plus sign (+); and if it is not heavy, leave the space blank.

(*b*) *Beginning.*—The time of beginning of the thunderstorm is

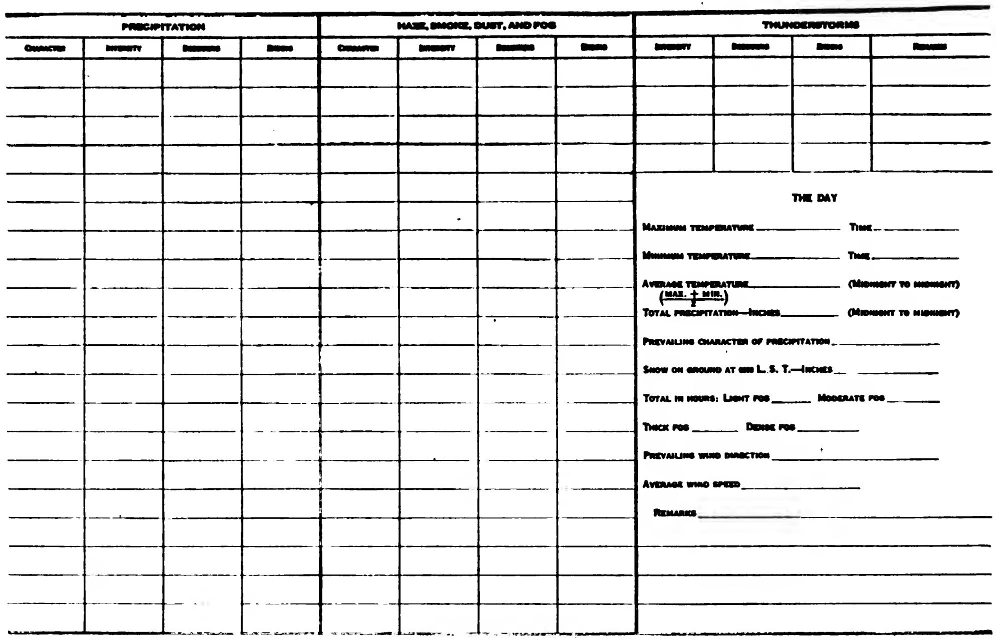


FIGURE 148.—Back page of Form No. 94.

recorded on the 24-hour clock system. If the station does not operate 24 hours each day, and the exact time is unknown, record DNA, or after midnight; and DNP, or before midnight. If the storm continued through from the previous day, record three dashes (– – –).

(c) *Ending.*—Record the ending time on the 24-hour clock system. If the station does not operate 24 hours per day, and the exact time is unknown, record DNA for "during night, a. m.," or after midnight, and DNP for before midnight or "during night, p. m.". If the storm continued through to the next day, record three dashes (– – –).

(d) *Remarks.*—Under "Remarks", enter any pertinent information about the thunderstorm deemed to be necessary to completely describe its occurrence.

(3) *The day.*—This section contains the summary of the weather for the day. Since all the information contained in this section is used to complete various other forms and records, it is essential that the method of making entries conforms with standardized practice.

(a) *Maximum temperature and time.*—The maximum temperature from midnight to midnight is recorded herein to the nearest whole degree. It is obtained from a Form No. 2, provided that the thermograph trace shows that the maximum for the day in question is recorded by the maximum thermometer. If the information cannot be taken from a Form No. 2, then it is obtained from a corrected thermograph trace. Obtain the time the maximum temperature occurred from the thermograph trace and record it in the space provided on a 24-hour clock system.

(b) *Minimum temperature and time.*—The minimum temperature from midnight to midnight is recorded herein to the nearest whole degree. It is obtained from a Form No. 2, provided that the thermograph trace shows the minimum for the day in question is recorded by the minimum thermometer. If the information cannot be taken from Form No. 2, it is then obtained from the corrected thermograph trace. Obtain the time at which the minimum temperature occurred from the thermograph trace and record it in the space provided for "Time." Use the 24-hour clock system, with 2400 denoting the end, and 0000 denoting the beginning of a day.

(c) *Average temperature.*—Record the average temperature from midnight to midnight to the nearest whole degree. It is obtained by dividing the algebraic sum of the maximum and minimum temperature by two.

(d) *Total precipitation.*—The total amount of precipitation from midnight to midnight is recorded to the nearest hundredth of an inch.

If the station has no operator on duty overnight and it is not equipped with a tipping bucket rain gage, the amount of precipitation for the day is estimated as accurately as possible.

(*e*) *Prevailing character of precipitation.*—The prevailing character of precipitation is the type of precipitation which has occurred the longest period of time during the day. The length of time each type prevailed is obtained from the precipitation column to the left of the reverse side of Form No. 94. To obtain the prevailing character, total the length of time all of the intensities of the same type of precipitation occurred. For example, the total time of S—, S, and S+ for the day gives the total hours and minutes of snow occurrring during the day; and if the length of time is not exceeded by any other phenomena, record S in the space provided. Use the literal teletype abbreviation and omit all intensity symbols. If the time of ending or beginning is marked, DNA or DNP, estimate the length of time as accurately as possible. If two types occur the same length of time, record the symbol for both types.

(*f*) *Snow on ground at 0800 LST (inches).*—The depth of snow obtained during the observation nearest to 0800 LST is recorded herein to the nearest tenth of an inch. If no snow is reported, leave the space blank; and if less than a tenth of an inch is reported, enter a capital T for trace.

(*g*) *Total hours, light fog, moderate fog, thick fog, and dense fog.*—The total hours of light, moderate, thick, and dense fog are computed by summing their times of duration from the column headed, "Haze, smoke, dust, and fog." Record the result to the nearest whole hour; and if no fog occurs, enter O.

(*h*) *Ground fog.*—The total number of hours of ground fog, regardless of intensity, are obtained and entered to the nearest whole hour in the space for "Remarks" on the reverse side of Form No. 94.

(*i*) *Prevailing wind direction.*—The prevailing wind direction will be filled in by noting the wind direction which occurred most frequently during the day. If two wind directions occur an equal number of times, both are entered. Use *only* the record observation on the front page of Form No. 94 in obtaining the prevailing wind direction. Enter in literal wind direction abbreviations.

(*j*) *Average wind speed.*—The average wind speed is obtained by totaling the wind speeds of all of the record observations and dividing by the number of observations. Use only record observations, and record the average speed to the nearest whole mile per hour.

(*k*) *Remarks.*—In addition to the ground fog entry referred to in

(*h*) above, record in the "Remarks" column any pertinent weather information which cannot be properly reported otherwise.

74. W. D., S. C. Form No. 94 (modified).—*a. General.*—(1) The modified type of Form No. 94 is essentially the same as Form No. 94. On the front page, the "Sky," "Classification," and "Wind shift" columns have been eliminated. A column for "Type" of observation has been added, and the wind direction and speed columns have been combined. On the reverse side the "Character" and "Intensity" columns have been combined under "Precipitation" and "Haze, smoke, dust, and fog;" spaces have been provided for entering total hours of "Ground fog," "Ceiling below 500 feet," "Ceiling below 5,000 feet," and "Overcast below 10,000 feet;" and a space for miscellaneous information has been provided.

(2) The entries on Form No. 94 are made with a moderately hard pencil. All information is put in chronological order in the proper columns as indicated by the headings. The form is not taken outside during the observation, but pertinent data of the observation are transferred to Form No. 94 as soon as is practicable. Duplicate entries will be accomplished in full, and ditto marks will not be used.

b. Front page.—On the front page of Form No. 94 are recorded the elements which are used in comparing the teletype weather reports.

(1) *Station.*—In the space reserved for "Station," record the complete designation of the station location, as Chanute Field, Illinois.

(2) *Date.*—Record here the month, day, and the year.

(3) *Type.*—The type of report is entered in the column provided, using the following designations: R for a record observation; S for a special observation; R/S for a record-special observation; and a check mark (✓) for a check observation.

(4) *Time.*—In the column headed "Time," record the time of the report, using the 24-hour clock system. The proper letter is entered in the parenthesis below the word "Time" to indicate the local time zone.

(5) *Ceiling.*—The ceiling value is entered in hundreds of feet for all values up to and including 20,000 feet. The value is given to the nearest 100 feet below 5,000 feet and to the nearest 500 feet above 5,000 feet. If no ceiling is reported, or if the value is above 20,000 feet, no entry is made. Place the letter E before estimated ceiling values, and the letter V after the figures representing the ceiling if the condition described is variable.

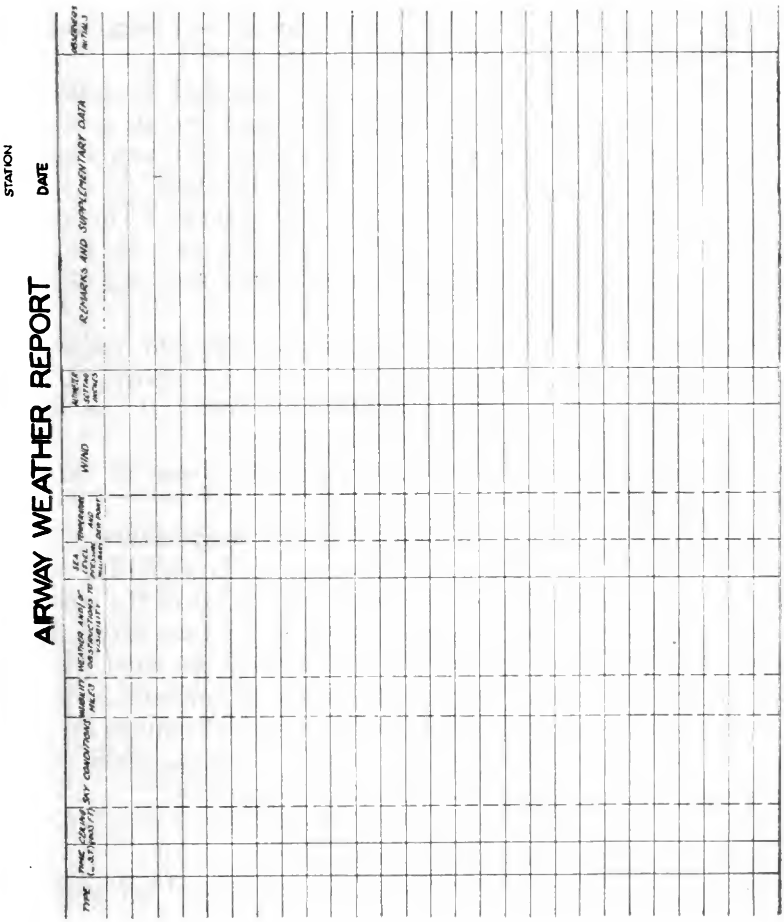


FIGURE 149.—Front page of modified type of Form No. 94.

(6) *Sky conditions.*—Sky condition refers to the coverage of clouds as is indicated in the teletype weather message. The recognized teletype symbols are used for indicating sky coverage. A maximum of two sky symbols is allowable. The height of the lower scattered clouds is indicated in hundreds of feet and placed before the scattered symbol. If the sky is obscured, the space is left blank; and if the sky is clear, use the clear symbol. A plus (+) sign preceeding the cloudiness symbol indicates dark, and a minus (—) sign indicates thin coverage.

(7) *Visibility.*—The visibility values are reported in miles and fractions thereof. The values which may be used are: 0, ⅛, ⅜, ¼, ½, ¾, 1, 1¼, 1½, 1¾, 2, 2¼, 2½, 3, 4, 5, 6, 7, 8, and 9. For any visibility values less than 7 miles, the restriction must be explained by some weather or obstruction to visibility element or elements. The absence of a visibility value indicates that the visibility is 10 miles or more. Variable visibility is indicated by a letter V following the visibility value.

(8) *Weather and/or obstruction to visibility.*—Herein record the active weather elements as they are given in a teletype report. Use the recognized literal weather element abbreviations. If no active weather element is occurring, leave the space blank.

(9) *Sea-level pressure.*—Record the sea-level pressure in millibars and tenths of millibars.

(10) *Temperature and dew point.*—Record the temperature in whole degrees followed by a slant line and the dew point in whole degrees.

(11) *Wind.*—Enter the wind direction to 16 points of the compass, using literal abbreviations, for example, NNE.; if a calm exists, record the letter C. Following the wind direction enter the wind speed in miles per hour. Character of gustiness, when appropriate, is entered immediately following the wind velocity, by use of the minus (—) sign to indicate fresh, and a plus (+) sign to indicate strong gusts. If the velocity is estimated, place a letter E after the velocity.

(12) *Altimeter setting.*—Record the altimeter setting to the nearest hundredth of an inch.

(13) *Remarks.*—In the "Remarks" column, record all pertinent weather information which cannot properly be described by recording the items preceding it on the form. Some stations which are designated to send out additional data groups at certain times, will insert the data in the "Remarks" column. They will separate the additional data from the teletype remarks with a slant line. A cloud report for each observation is entered to the right in the "Remarks" column following the remarks pertaining to teletype report and the additional data

groups. It is made up as follows: First, give by numerical designation the tenths covered, then give the type followed by a dash (–) and the direction from which the clouds are moving. The type and direction are given in the abbreviated literal forms. List all the layers, placing the higher cloud types above; for example:

REMARKS

	6 Ac–SE
FOG BNK S/507 55062	
	2 Cu–E

(14) *Observer's initials.*—The observer will record his initials after each observation.

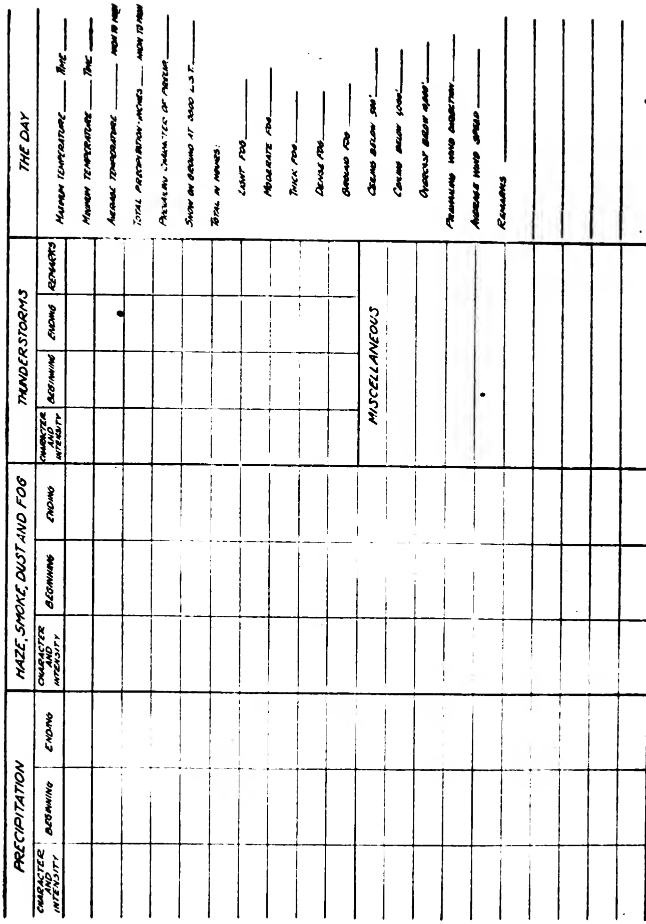
c. Reverse side.—The reverse side of Form No. 94 is used to record the character and duration of all active weather elements occurring during the day, and also to summarize the weather for each day from midnight to midnight.

(1) *Precipitation, and haze, smoke, dust, and fog.*—Under the column headed "Precipitation," record all the weather elements which are active precipitation. In the column headed "Haze, smoke, dust, and fog," record these four elements causing limitation of visibility. The rules governing the entries for character, intensity, beginning, and ending are identical and are discussed in the following paragraphs.

(*a*) *Character and intensity.*—The characters of the phenomena are entered in chronological order in this column. The entries are made in the recognized literal teletype abbreviations. The intensity of each phenomenon is indicated after the character by recording a minus sign (—) for light, a plus sign (+) for heavy intensity. Moderate intensity is indicated by the lack of a symbol.

(*b*) *Beginning.*—Record the time the phenomenon began, using the 24-hour clock system. If the station does not operate on a 24-hour basis and the time therefore is unknown, record DNA for "during night, AM" or after midnight, and DNP for "during night, PM" or before midnight. If the precipitation continued from the previous day, record three dashes (– – –).

(*c*) *Ending.*—Record the time the phenomenon ended, using the 24-hour clock system. If the station does not operate 24 hours each day, and the exact ending time is unknown, record DNA for "during night, AM," or after midnight. DNP is used for "during night, PM," or before midnight. In the event that the precipitation continues beyond midnight, indicate by recording three dashes (– – –).



PRECIPITATION			HAZE, SMOKE, DUST AND FOG			THUNDERSTORMS			
CHARACTER AND INTENSITY	BEGINNING	ENDING	CHARACTER AND INTENSITY	BEGINNING	ENDING	CHARACTER AND INTENSITY	BEGINNING	ENDING	REMARKS

MISCELLANEOUS

THE DAY

MAXIMUM TEMPERATURE ____ TIME ____
MINIMUM TEMPERATURE ____ TIME ____
AVERAGE TEMPERATURE ____ MIDN TO MIDN
TOTAL PRECIPITATION-INCHES ____ MIDN TO MIDN
PREVAILING CHARACTER OF PRECIP. ____
SNOW ON GROUND AT 0000 L.S.T. ____
TOTAL IN HOURS:
LIGHT FOG ____
MODERATE FOG ____
THICK FOG ____
DENSE FOG ____
GROUND FOG ____
CEILING BELOW 500' ____
CEILING BELOW 1000' ____
OVERCAST BELOW 4,000' ____
PREVAILING WIND DIRECTION ____
AVERAGE WIND SPEED ____
REMARKS ____

FIGURE 150.—Back page of modified type of Form No. 94.

(2) *Thunderstorms.*—All thunderstorms are recorded in this column.

(*a*) *Character and intensity.*—Character refers to whether or not the thunderstorm is occurring with or without rain. If it is occurring with rain, record the symbol $\dot{\ulcorner}\!<$; and if it is a dry thunderstorm, record $\ulcorner\!<$. The intensity of the storm is indicated after the character symbol. Thunderstorms may be of two intensities, "heavy thunderstorm" or "thunderstorm." If the thunderstorm is heavy, record a plus (+) sign; and if it is not heavy, record nothing after the character.

(*b*) *Beginning.*—The time of beginning of the thunderstorm is recorded on the 24-hour clock system. If the station does not operate 24 hours each day, and the exact time is unknown, record DNA for "during night, AM" or after midnight, and DNP for "during night, PM" or before midnight. If the storm continued through from the previous day, record three dashes (- - -).

(*c*) *Ending.*—Record the ending time on the 24-hour clock system. If the station does not operate 24 hours each day, and the exact time is unknown, record DNA for "during night, AM" or after midnight, and DNP for "during night, PM" or before midnight. If the storm continued through to the next day, record three dashes (- - -).

(*d*) *Remarks.*—Under "Remarks" enter any pertinent information about the thunderstorm deemed to be necessary to completely describe its occurrence.

(3) *The day.*—This section contains the summary of the weather for the day. Since all the information contained in this section is used to complete various other forms and records, it is essential that the method of making entries conforms with standardized practice.

(*a*) *Maximum temperature and time.*—The maximum temperature from midnight to midnight is recorded herein to the nearest whole degree. It is obtained from a Form No. 2 provided that the thermograph trace shown that the maximum for the day in question is recorded by the maximum thermometer. If the information cannot be taken from a Form No. 2, then it is obtained from a corrected thermograph trace. Obtain the time the maximum temperature occurred from the thermograph trace and record it in the space provided on a 24-hour clock system.

(*b*) *Minimum temperature and time.*—The minimum temperature from midnight to midnight is recorded herein to the nearest whole degree. It is obtained from a Form No. 2, provided that the thermograph trace shown for the minimum for the day in question is recorded by the minimum thermometer. If the information cannot be taken from Form No. 2, it is then obtained from the corrected thermograph trace.

Obtain the time at which the minimum temperature occurred from the thermograph trace and record it in the space provided for "Time." Use the 24-hour clock system, with 2400 denoting the end, and 0000 denoting the beginning of a day.

(c) *Average temperature.*—Record the average temperature from midnight to midnight to the nearest whole degree. It is obtained by dividing the algebraic sum of the maximum and minimum temperature by two.

(d) *Total precipitation.*—The total amount of precipitation from midnight to midnight is recorded to the nearest hundredth of an inch. If the station has no operator on duty over night, and it is not equipped with a tipping bucket rain gage, the amount of precipitation for the day is estimated as accurately as possible.

(e) *Prevailing character of precipitation.*—The prevailing character of precipitation is the type of precipitation which has occurred the longest period of time during the day. The length of time each type prevailed is obtained from the precipitation column to the left of the reverse side of Form No. 94. To obtain the prevailing character, total the length of time all of the intensities of the same type of precipitation occurred. For example, the total time of S—, S, and S+ for the day gives the total hours and minutes of snow occurring during the day; and if the length of time is not exceeded by any other phenomena, record S in the space provided. Use the literal teletype abbrevation and omit all intensity symbols. If the time of ending or beginning is marked, DNA or DNP, estimate the length of time as accurately as possible. If two types occur the same length of time, record the symbol for both types.

(f) *Snow on ground at 0800 LST* (*inches*).—The depth of snow obtained during the observation nearest to 0800, LST, is recorded herein to the nearest tenth of an inch. If no snow is reported, leave the space blank; and if less than a tenth of an inch is reported, enter a capital T for trace.

(g) *Total hours, light fog, moderate fog, thick fog, dense fog, and ground fog.*—The total hours of light, moderate, thick, and dense fog are computed by summing their times of duration from the column headed "Haze, smoke, dust, and fog." The total hours of ground fog, regardless of intensity, are obtained from the same source. Then the values are recorded to the nearest whole hour in the spaces provided. If no fog occurs, record 0.

(h) *Total hours, ceiling below 500, 1,000, and 10,000 feet.*—From the front of Form No. 94, obtain the total hours of ceiling below 500 feet,

1,000 feet, and 10,000 feet and record in the proper spaces. If no ceiling value is given for a range, record 0.

(*i*) *Prevailing wind direction.*—The prevailing wind direction will be filled in by noting the wind direction which occurred most frequently during the day. If two wind directions occur an equal number of times, both are entered. Use *only* the record observation on the front page of Form No. 94 in obtaining the prevailing wind direction. Enter literal wind direction abbreviations.

(*j*) *Average wind speed.*—The average wind speed is obtained by totaling the wind speeds of all of the record observations and dividing by the number of observations. Use only record observations, and record the average speed to the nearest whole mile per hour.

(*k*) *Remarks.*—In the "Remarks" column, record any pertinent weather information which cannot be properly reported otherwise.

(4) *Miscellaneous.*—If some phenomena occur which require special attention, or some entry needs to be elucidated, record such information under "Miscellaneous."

75. W. D., S. C. Form No. 97.—*a. General.*—Form No. 97 is the record sheet used on the double register drum. It contains space for a 24-hour record of wind speed and direction. The chart is changed each day exactly at noon.

b. Preparing the chart.—The entries are written, typed, or stamped as convenient.

(1) *Station.*—In the upper right-hand corner above the grid of the chart, record the name of the station and the state it is in, as Chanute Field, Illinois.

(2) *Six-hourly wind record.*—To the left of the ruled section enter the total miles of wind which passed by the station during each of the four 6-hour periods. The sum of the numbers is obtained and recorded below the numbers. This data is worked up only if record is desired for local needs.

(3) *Number of miles during past 12 hours.*—Herein record the number of miles of wind which passed the station during the last 12 hours preceding the installation of the chart. This entry is obtained from the previous chart, and is made only when wind data sheets are worked up for local needs.

(4) *Total movement.*—The total number of miles of wind that passed the station from midnight yesterday to midnight on the sheet in question. Total movement records are made only when wind data is worked up for local needs.

(5) *Dial reading at 12 noon.*—This refers to the anemometer dial reading which is obtained at noon on the first day of each month and

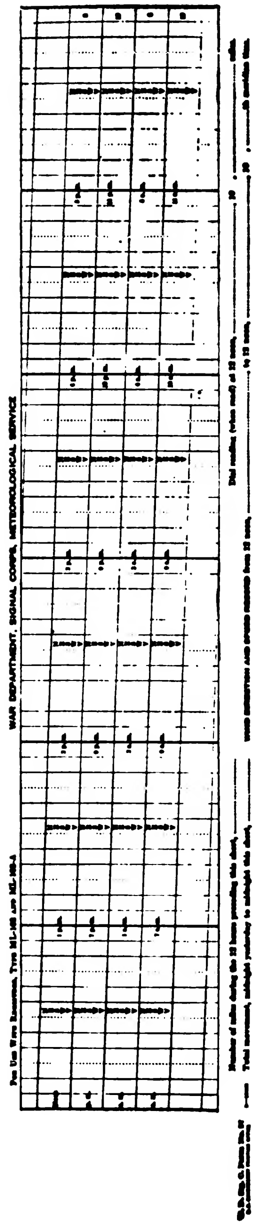


FIGURE 151.—Form No. 97.

every Monday thereafter. In the first space enter the month and the day, followed by the year, and finally, the dial reading to the nearest whole mile. This reading is entered only on the days it is taken.

(6) *Wind direction and speed record.*—Herein record the days the chart is to cover. In the proper space indicate the meridian of the time zone used.

(7) *Incomplete records.*—(*a*) In the event that the double register fails to function properly, the wind record will, of course, be incomplete, and steps must be taken to maintain an accurate record. Each time the observation is made, the double register will be examined to see whether or not it is working properly. If the anemometer cups and dials are turning, but the record is not being made, a dial reading will be made at once and entered on the register sheet together with the time at which it was made. A serviceable anemometer should be installed as soon as possible, recording its dial reading adjacent to that of the anemometer, which has been removed for repair. Until the regular anemometer is installed, dial readings will be taken at 0800 LST and noon every day during the incomplete record. These readings are entered on the register sheet under the time at which they were obtained. The data will be interpolated when the loss of the record is less than 24 hours. Short breaks in the record may be estimated by the observer. He is to use every possible source of information at his disposal to obtain the correct record. In all cases an explanatory note will be entered on all forms where the data are recorded, stating that the data are interpolated or estimated.

(*b*) In the event that the record is lost for a period of 24 hours or more, blank sheets will be prepared and included with the monthly reports. The prepared sheet will contain the name of the station, the dates, and such data as can be obtained.

(*c*) Whenever the instrument has not been running on correct time, a note is made to indicate the true time of the record.

(*d*) When the anemometer is changed, a note will be made on the lower margin of the anemometer record sheet, giving the date and the hour of the change and the dial reading of both old and new instruments. If changed at 1200 LST, both readings will be recorded on the sheet just taken from the register. Anemometers should not be removed while contact is being made. Example of note for change of anemometers follows:

> Station anemometer removed at 1030 EST, July 13, for cleaning; dial reading, 581 miles. Extra anemometer installed; dial reading, 487 miles.

Extra anemometer removed at 1115 EST, July 23; dial reading, 503 miles. Station anemometer reinstalled; dial reading, 16 miles.

(8) *Wind data; entry on sheet.*—Wind data from the wind register sheet will normally not be obtained except to determine the extreme speed. When further data are obtained for local needs, the instructions below are followed:

(*a*) The prevailing wind direction for each hour will be entered on the register sheet as near the center of the record space for the hour as practicable. If two or more directions are observed an equal number of times, consider the directions adjacent in determining the direction to be entered, as prevailing. When the movement for any hour is

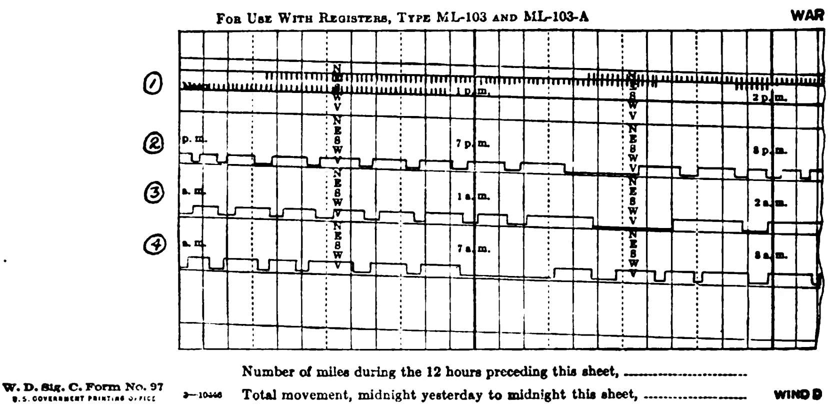


FIGURE 152.—Part of double register wind record.

entered as 0, the direction for that hour will be 0. Entries will be printed as N., NE., E., etc.

(*b*) The wind movement for each hour will be entered on the register sheet near the right end of the record for the hour.

c. Method of obtaining wind direction.—(1) The wind direction record of a double register consists of two parallel lines from which the direction spurs project perpendicularly. The spurs are about $\frac{6}{10}$-inch long, and a direction spur or a set of spurs is formed once every minute. Therefore, they are placed at every minute interval on the chart. The spurs which project above the upper line, indicate northerly directions, while those below the line indicate easterly directions. The spurs above the lower line indicate southerly directions, while those below indicate westerly directions. If a northeasterly wind is blowing, the spurs will be made to the north and east simul-

taneously. Also, if spurs appear above the lower line and below the upper line simultaneously, a southeast wind is blowing at that instant. Eight wind directions can be indicated on the chart.

(2) The prevailing wind direction for an hour is obtained by counting the spurs for each of the eight wind directions. Then, since the spurs are recorded at minute intervals, the number of spurs for any one direction will give the total number of minutes the wind prevailed in that direction. The wind which prevailed the greatest number of minutes is taken as the prevailing direction. If two wind directions prevail for an equal number of minutes during the hour, use the prevailing wind direction of the previous hour to determine which direction is to be used. For example, if an east wind and a northeast wind had blown for an equal number of minutes during the hour and the prevailing wind direction for the previous hour was southeast, the east wind direction would be chosen. This example is illustrated by the wind directions for the first 2 hours of line of figure 152.

d. Method of determining wind speed.—The wind speed trace is composed of a horizontal line which is interrupted by a series of "spurs" which project beneath the line. The mechanism of the double register is so arranged that when a mile of wind passes the station, the wind velocity pen falls below the line and continues a short distance horizontally and then springs back up to the original level, producing a spur beneath the line. The short vertical line produced when the pen falls is called the "break", and the vertical line produced when the pen springs back into place is called the "make." Therefore, the distance between any two successive makes or breaks on the chart represents the passage of 1 mile of wind. Since the clockwork moves the chart at a known regular velocity, the distance between two successive makes or two successive breaks indicates the length of time required for a mile of wind to pass by the station. The wind speed may be obtained by any of the following methods which is applicable:

(1) If the speed is more than 12 miles per hour, count the number of spaces and fractions of spaces between makes or breaks which are included within a 5-minute time interval preceding the moment considered. Multiply the result by 12 to obtain the correct answer. For example, suppose there are $1\frac{1}{4}$ spaces occurring during the 5 minutes between 0740 and 0745. Then $1\frac{1}{4}\times12=15$. The speed of the wind is 15 miles per hour. Since a space represents a mile of wind, the same example could be stated thus: Suppose that $1\frac{1}{4}$ miles of wind passed the station between 0740 and 0745, what is the speed of the wind? The solution is the same; $1\frac{1}{4}\times12=15$ miles per hour.

(2) By using S. C. Form No. 99, which is the wind velocity scale designated for the quadruple register, any velocity can be obtained by measuring the distance between makes or breaks for any 1 mile with the minute scale. This scale reads directly the minutes needed for a mile of wind to pass the station. The speed is then obtained by dividing 60 by the number of minutes obtained. For example, the time required for 1 mile of wind to pass by the station is found to be 7 minutes. Then $\frac{60}{7}=8\frac{4}{7}$ miles per hour, which is recorded as 9 miles per hour.

(3) Extreme speed is obtained by finding on the trace, which is the shortest distance between any two successive makes or breaks and then measuring the time which elapsed between the two. Divide the time into 60 and the quotient will be the extreme speed. For example, the space between two makes nearest to each other is found to be 2 seconds. Then $\frac{60}{2}=30$, and the extreme speed is 30 miles per hour.

(4) W. D., S. C. Form No. 99 is the War Department wind velocity scale for determining velocities, as recorded on Form No. 100. It can be used to determine the speed of any mile of wind, provided its speed is not below 5 miles per hour and does not exceed 78 miles per hour. To use it move the scale until two defining lines of a speed exactly coincide with the two make or break lines in question. Then read the velocity directly from the chart.

e. Method of determining miles passed.—In order to facilitate reading of the wind speed trace, the ninth and tenth spurs have been joined together, producing one long spur for every 10 miles of wind which passed the station. To determine the total miles of wind passing the station, count the number of spurs occurring during that time. Consider the wind trace for the first hour of line 2 in figure 152. Observe that the first vertical line produced during the hour is a make. To obtain the miles passed, count the number of makes occurring. This is found to be seven. Therefore, 7 miles of wind passed the station. The correct figure, in this case, can be determined by counting the number of whole spurs below the line. Now, observe the trace for the first hour of line 3. The first vertical line produced is a break. To obtain the number of miles passed, count the number of breaks. This gives 6 miles. It will be observed that if the makes are counted in this example, the answer obtained will be seven, which is erroneous. The second hour on line 2 can be used for illustrating the double spur. The second spur is noted to be approximately twice the length of the other spurs, and so it must be a double spur. In counting the double

spur, both the make and the break are considered. There are four complete spurs below the line, and since one of these is a double spur, 5 miles of wind passed during the hour. The miles can best be determined by counting *either* the makes or the breaks of the short spurs as is required and then count *both* the make and break of the long spur. This will also give a total of 5 miles. Finally observe line 4. Since the first vertical line is a break, count the total number of breaks, which is found to be six. Then by observing the succeeding spur, it is noted it extends past the hour line and that it also is a long spur. Therefore, its make must be added to the six breaks, giving 7 miles of wind passing the station during the first hour of line 4.

76. W. D., S. C. Forms No. 98 and No. 111 (Barograph Record Sheet).—*a. General.*—Form No. 98 is the record sheet of a microbarograph. Each chart records a continuous pressure record for 4 days. Form No. 111 is the record sheet for a barograph, and each chart records the pressure for 7 days.

b. Preparation of chart.—Before the chart is placed into use it is trimmed and certain entries are made upon it. The entries may be typed, stamped or written plainly.

(1) *Trimming.*—The chart is trimmed on the bottom along the trimming line. Then one-half of the right margin is cut off to permit placing the edge completely under the spring clip.

(2) *Station, period and time.*—Each sheet will have the name and state of the station, the period of time covered, and the meridian of the time zone entered in the lower left-hand corner if it does not interfere with the record. If it does, place the entry in the upper left-hand corner. Example:

Chanute Field, Illinois.
For period ending March 20, 1942.
90th meridian time.

If the sheet is the first chart of the month, information as to when the pen is touched is also included. Example:

Chanute Field, Illinois.
For period ending March 4, 1942.
Pen touched Daily at 7:20 AM LST.
90th meridian time.

If the chart is Form No. 111 the word "week" may be used in the place of "period."

(3) *Day.*—A figure to represent each day of the month covered by the chart is placed along upper edge above the ruled section as near the noon line as practicable.

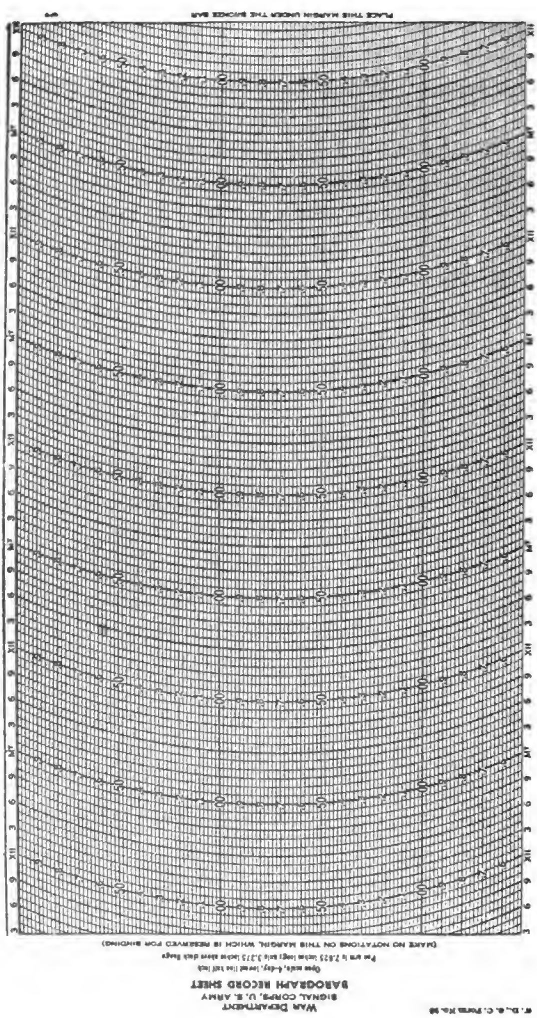


FIGURE 153.—Form No. 98.

(4) *Stations having low pressure.*—At stations where the pressure is such that the record might pass off the edge of the sheet or not all be included by the rulings, the observer will change the numbering of the lines by a convenient whole number and adjust the pen of the instrument accordingly.

(5) *Commercial forms.*—Occasionally some commercial type of a microbarograph chart may be employed which may have blanks for entering various data. In this event, leave the spaces provided blank and enter only the information required on Form No. 98 as prescribed above.

c. Changing the chart.—(1) Before the chart is changed, the correct station pressure is obtained from the mercurial barometer. This reading is entered on the ending of the trace of the chart removed and on the beginning of the chart to be put into use. The remainder of the changing is as follows. By the use of the pen arm release, raise the pen arm off the chart. Open the cover, remove the drum, and then remove the old chart. The best practice is to place the used chart into a folder made of two blotters which dry and protect it. Wind the clock. Put in the new chart making sure that it rests snugly on the shoulder of the drum, is tight, and that it is correctly placed on the drum to have both ends under the spring clip. Replace the drum making the major adjustment for time. Ink the pen and then lower it to within ⅛ inch of the chart. Make the pressure adjustment if necessary, followed by the minor adjustment for time. Close the cover and lower the pen to the chart. Make sure that the clock is running and that the pen is feeding ink properly.

(2) The microbarograph chart is changed the first day of the month and every fourth day thereafter. Form No. 111 is changed the first day of the month and every Monday thereafter. The best practice in changing charts is to set a specific hour for the change and then do it at the time specified. The time found to be most satisfactory is 10:00 AM LST.

d. Corrections.—Data obtained from the observation of the mercurial barometer are, of course, more accurate and reliable than that obtained from the barograph or microbarograph trace. Therefore, when the records do not agree, the mercurial barometer is taken as being correct and the traces on Forms Nos. 98 and 111 are corrected to agree with the data obtained. The correct barometer reading is entered to the nearest hundredth inch at the beginning and ending of each trace. Unless there is local need for the correct pressure data from the barograph sheet, no corrections will be applied. If such data are required, the following rules will be observed:

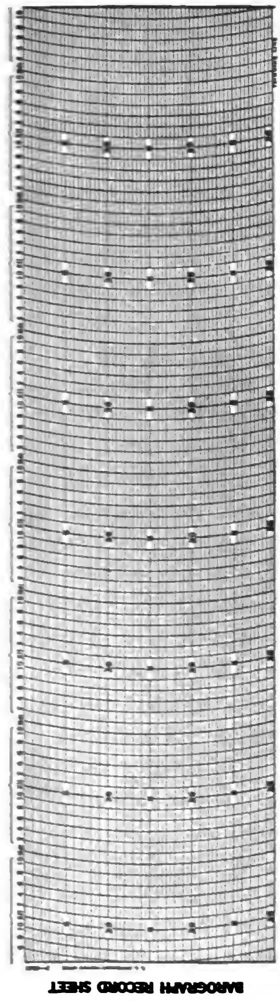


FIGURE 154.—Form No. 111.

(1) Corrections will be placed above the trace in red ink.

(2) They will be applied to the ending and beginning of the trace. and for each time the pen is touched.

(3) The corrections will be accurate to the nearest hundredth of an inch.

(4) The correction will be prefixed by the proper symbol to indicate whether it is added to or subtracted from the reading to obtain the correct station pressure. If the barometer reads 0.02 inch higher than the barograph trace, then a +0.02 is entered at the point above the trace. If the correction is zero, enter ±0.00.

e. Incomplete records.—When the recording instrument fails to record a position of the trace for the day, the gap will be filled in by interpolation, if possible, and plainly marked as such. An explanatory note will be entered on the record sheet, giving the reason for loss of record.

f. Incorrect time.—When the instrument is not running on correct time, a note will be made on the sheet, indicating the correct time or number of minutes the clock is fast or slow at time of observation. This fact will be considered in taking off the data so that it will be in the true standard time.

77. W. D., S. C. Form No. 100.—*a. General.*—Form No. 100 is the record sheet used on the quadruple register drum. It contains space for a 24-hour record of rainfall, wind speed, and wind direction. The chart is changed each day at exactly noon.

b. Preparing chart.—The entries are written, typed or stamped.

(1) *Station.*—Herein record the name of the station and the state it is in, as Chanute Field, Illinois.

(2) *Precipitation.*—In the space provided, record the amount of precipitation to the nearest hundredth of an inch as obtained during the observation nearest to 0800 LST from the tipping bucket record and from the stick measurement. When the amounts by register and stick measurement at an observation differ by 10 percent or more, the matter should be investigated. The stick measurement will, however, be taken as the correct measurement unless there is evidence that it is not correct. A discrepancy between the tipping bucket record and stick measurement is not infrequent. It may be due to defective action of the recording mechanism under various conditions, as moisture, rapidity of rainfall, cleanliness, etc.

(3) *Six-hourly wind record.*—In the blank spaces between the precipitation record and the grid are recorded the total miles of wind which passed by the station during each 6-hour period. The sum of the four

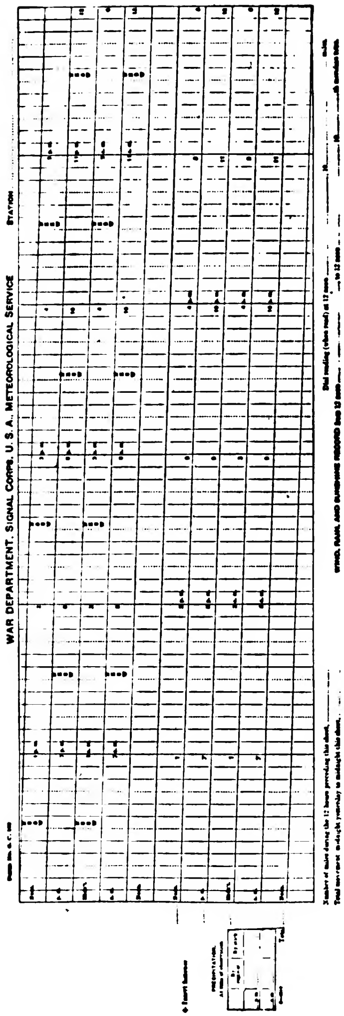


FIGURE 155.—Form No. 100.

-hour periods is given in the space marked. This data is worked up only if the record is desired for local needs.

(4) *Number of miles of wind during past 12 hours.*—Herein record the number of miles of wind which passed the station during the past 12 hours preceding the changing of the chart. This entry is obtained from the previous chart and is made only when the data sheets are worked up for local needs.

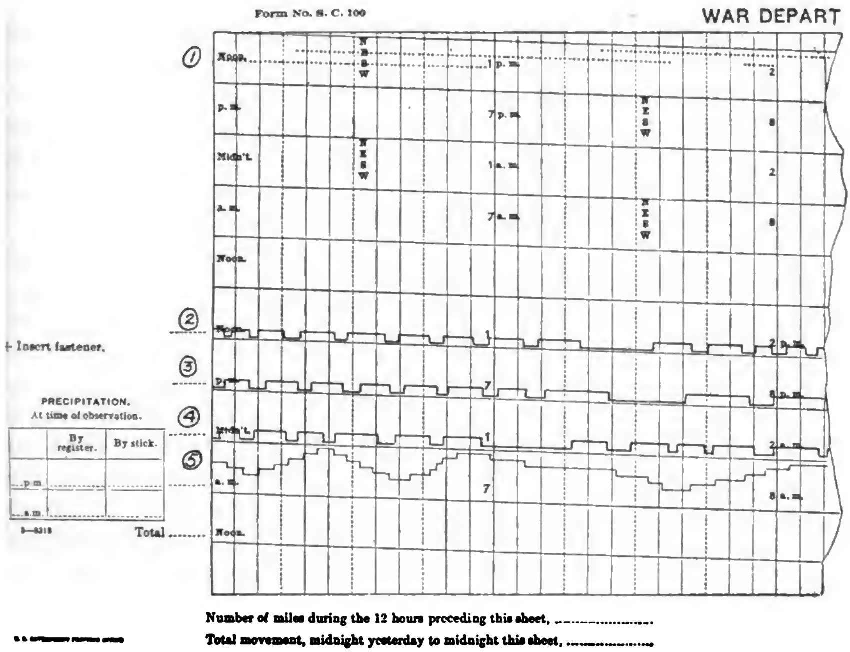


FIGURE 156.—Part of quadruple register trace.

(5) *Total movement.*—The total number of miles of wind that passed the station from midnight to midnight is recorded herein. Total movement records are obtained only for local needs.

(6) *Dial reading at 12 noon.*—This refers to the anemometer dial reading which is obtained at noon the first day of each month and each Monday thereafter. In the first space enter the month and the day followed by the year and, finally, the dial reading to the nearest whole mile. This reading is entered only on the days it is taken.

(7) *Wind direction and speed record.*—Herein record the days the chart is to cover. In the proper space indicate the meridian of the time zone used.

(8) *Incomplete records.*—Incomplete records will be completed as described in paragraph 75*b*(7).

(9) *Wind data.*—Wind data will be obtained according to instruction given in paragraph 75*b*(6).

c. Method of obtaining wind direction.—(1) The wind direction record of a quadruple register consists of a series of dots produced by the wind direction pens at minute intervals. Each direction pen produces its dots in a straight line. One row of dots is produced for each of the four cardinal directions. Dots on the uppermost line indicate northerly directions while those on the second line from the top record easterly directions. The third line from the top indicates southerly directions, while the last line indicates westerly directions. If a northeast wind is blowing, the dots will be made for northerly and easterly directions simultaneously. In the same way, if dots appear on the south and east lines simultaneously, a southeast wind is blowing at that instant. Eight wind directions can be thus indicated on the chart.

(2) The prevailing wind direction for any hour may be obtained by counting the dots representing each of the eight wind directions. Then, since the dots are recorded at minute intervals, the number of dots for any direction will give the total number of minutes the wind prevailed in that direction. The wind which prevailed for the greatest number of minutes is taken as the prevailing direction. If two directions prevail for an equal number of minutes during the hour use the prevailing wind direction of the previous hour to determine the direction to be used. For example, if an east wind and a northeast wind had persisted for an equal number of minutes during the hour and the prevailing direction for the previous hour was southeast, the east direction would be chosen. This example is illustrated by the wind directions for the first 2 hours of line (1) of figure 156.

d. Method of determining wind speed.—The method of determining the wind speed from a quadruple and double register sheet is explained in paragraph 75*d*.

e. Method of determining miles passed.—The method of determining the number of miles of wind which pass the station in a given period of time is explained in paragraph 75*e*.

f. Method of obtaining depth of rainfall.—(1) The rainfall record of the quadruple register is a series of horizontal lines, arranged in steps. The steps go upward for 0.05 inch of rain and recede for the following five. To obtain the depth of rainfall over any period of time, count the number of steps within the time period in question. For example, in the rain trace shown on line (5) of figure 156, the pen has risen 10 times and fallen 8 times during the first hour. Therefore, 0.18 inch of rainfall fell during the hour.

(2) A convenient method of measuring the rate of fall over a short ɪeriod of time is to employ the minute scale of the wind velocity scale o determine the number of minutes which elapsed while a given mount of rain fell.

g. Sunshine record.—The sunshine recorder is no longer used at ɪrmy Air Forces weather stations.

78. W. D., S. C. Form No. 104 (Record of Wind Direction and **/elocity).**—*a. General.*—Form No. 104 is the chart used with the nemoscope, a device which measures and records instantaneous wind peed and direction.

b. Method of preparation.—The entries are written, typed or tamped, as convenient.

(1) *Station.*—Record the name of the station and its location, as, Chanute Field, Illinois..

(2) *Date.*—Enter the inclusive dates covered by the record.

(3) *Meridian time.*—Record the meridian of the time zone used.

(4) *Remarks.*—Record any pertinent remarks which may be deemed ɪecessary.

79. W. D., S. C. Form No. 120-A.—*a. General.*—Form No. 120-A s the record sheet of the thermograph. It presents a continuous emperature record for a period of 7 days.

b. Preparing the chart.—Before the chart is placed into use, it is trimmed and certain entries are made. These entries may be typed, stamped or written plainly in ink.

(1) *Trimming.*—The chart is trimmed on the bottom along the trimming line indicated there. One half of the right margin is trimmed off to permit placing the edge completely under the spring clip of the clock drum.

(2) *Station, period and time.*—Each sheet will have the name and location of the station, period of time covered, and the meridian of the time zone, indicated. These entries will be made in the lower left corner, so located as not to interfere with the record trace. If, in a given case, this is not possible, the entry should be made in the upper left corner. An example of such an entry follows:

Chanute Field, Illinois.
For week ending March 22, 1942.
90th meridian time.

If the sheet is the first record of the month, information as to when the pen is touched is also included. Example:

Chanute Field, Illinois.
For period ending April 5, 1942.

Pen touched daily at 7:20 AM, LST.
90th meridian time.

(3) *Day.*—A figure to represent each day of the month covered by the chart is placed along the upper edge, above the ruled section as near the noon line as practicable.

(4) *Temperature ranges above or below chart.*—At stations where the temperature extremes are such that the record might pass off the edge of the sheet, or not all be included by the rulings, the observer will change the numbering of the lines by converting a whole number and adjust the pen of the instrument accordingly.

c. Changing charts.—(1) The thermograph chart is changed the first day of the month and each Monday thereafter. The best practice in changing charts is to select a specific hour for the change and always observe the time specified. The time found to be most satisfactory is 10:00 AM, LST.

(2) Before the thermograph sheets are changed, the correct temperature is obtained from the dry thermometer. This reading is entered to the nearest tenth of a degree.

(3) By the use of the pen arm release, raise the pen off the chart. Open the cover, remove the drum, and then remove the old chart. The best practice is to place the used chart into a folder made of two blotters which dry and protect it. Wind the clock. Put on the new chart, making sure that it is tight, rests snugly on the shoulder of the drum, and is correctly placed on the drum with both ends under the spring clip. Replace the drum, making the major adjustment for time. Ink the pen and then lower it to within ⅛ inch of the chart. Make the temperature adjustment if necessary, followed by the minor adjustment for time. Close the cover and lower the pen to the chart. Make sure that the clock is running and that the pen is feeding ink properly.

d. Corrections.—Readings obtained by observation of the standard thermometer are considered more accurate and reliable than the data obtained from the thermograph trace. When the reading of the trace does not agree with the reading of the dry bulb thermometer, the dry bulb reading is taken as being correct and the trace is corrected accordingly. The correct thermometer reading is entered at the beginning and at the end of each trace. Unless there is a local need for temperature data from the thermograph sheet, no corrections will be applied. If any such data is required, the following rules will be applied.

(1) Corrections will be placed above the trace in red ink.

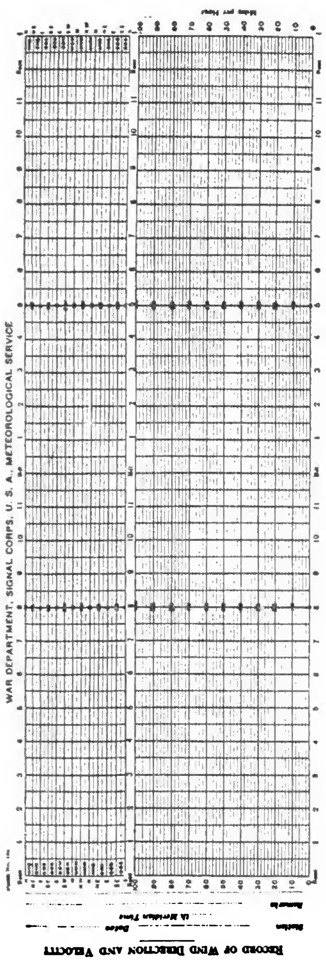


FIGURE 157.—Form No. 104.

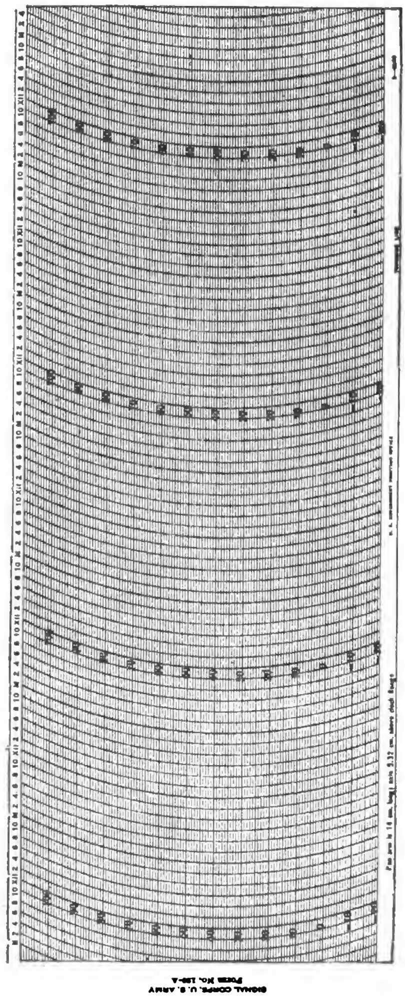


FIGURE 158.—Form No. 120-A.

(2) They will be applied to the beginning and end of the trace, for each time the pen is touched, and for every maximum or minimum temperature except when they occur during sending of thermograph.

(3) The corrections will be accurate to the nearest whole degree.

(4) The correction will be prefixed by the proper symbol to indicate whether it is added to or subtracted from the trace reading to obtain the correct station temperature. If the thermometer reads 2° lower than the thermograph trace, then a −2 will be entered at the point above the trace. If the correction is zero, enter ±0.

e. Incomplete records.—When the recording instrument fails to record a portion of the trace for the day, the gap will be filled in by interpolation, if possible, and plainly marked as such. An explanatory note will be entered on the second sheet giving the reason for loss of record.

f. Incorrect time.—When the instrument is not running on correct time, a note will be made on the sheet indicating the correct time or number of minutes the clock is fast or slow at the time of observation. This fact will be considered in extracting data from the trace so that proper values will be obtained.

g. Method of determining correct temperature.—When determining temperature readings from the thermograph sheets, the corrections entered on the thermograph sheets will be considered. Correction for hours between regular observations and the occurrence of maximum and minimum temperatures can be obtained by simple interpolation. For example, suppose that the correction at the 0800 LST observation is plus 2° and that the maximum temperature occurred at 1400 LST with a minus 1° correction. This gives a 3° change in error in the 6 hours or 1° for each 2 hours. Under these circumstances, 2° should be added to the indications of the trace for the hour of 0800 and 0900 LST, 1° should be added to the indication of the trace for 1000 LST, and the indications of the trace considered correct for hours of 1100, 1200, and 1300 LST. This interpolation may be done graphically by drawing lines very lightly on the thermograph sheet. A convenient horizontal line away from the trace is chosen as a zero line. In the case mentioned above, a dot is placed at the intersection of the line 2° above the zero line and the 0800 LST line; another dot is placed at the intersection of the 1400 LST line and a line 1° below the zero line. A fine line is drawn connecting these two dots. The number of degrees that this pencil line is above or below the zero reference line on the sheet at any particular hour is the number of degrees that should be added to or subtracted from the indication of the trace for that particular hour.

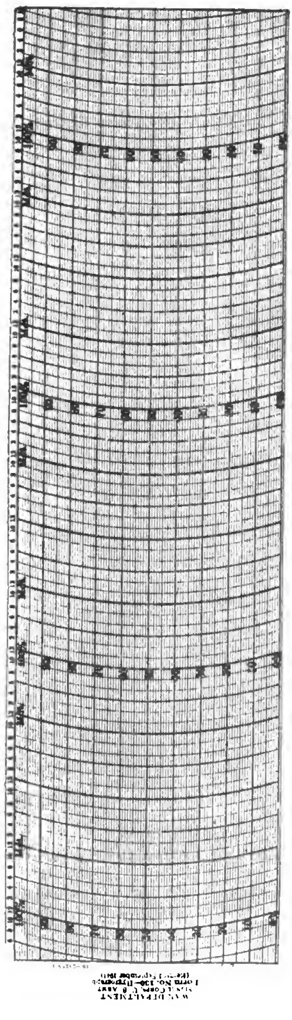


FIGURE 159.—Form No. 130.

80. W. D., S. C. Form No. 130 (Hygrograph).—*a. General.*—Form No. 130 is the hygrograph sheet. It furnishes a continuous record of the relative humidity for 7 days.

b. Preparing chart.—Before the chart is placed in use it is trimmed and certain entries are made upon it. The entries may be stamped, typed or written plainly in ink.

(1) *Trimming.*—The chart is trimmed on the bottom along the trimming line. One half of the right margin is trimmed off to permit placing the edge completely under the spring clip.

(2) *Station, period and time.*—Each sheet will have entered on it the name and station, period of time covered and the meridian of the time zone used. This entry is made in the lower left corner of the chart. If it then interferes with the trace, it is placed in the upper left corner. Example:

Chanute Field, Illinois.
For week ending March 22, 1942.
90th meridian time.

If the sheet is the first one of the month, information as to when the pen is touched is also included. Example:

Chanute Field, Illinois.
For period ending April 5, 1942.
Pen touched daily at 7300 AM LST.
90th meridian time.

(3) *Day.*—A figure to represent each day of the month covered by the chart is placed along the upper edge above the ruled section, as near the noon line as practicable.

c. Changing the chart.—(1) The hygrograph chart is changed the first day of the month and every Monday thereafter. The best practice in changing charts is to choose a specific hour for the change and adhere always. Change sheets at the time specified. The time found to be the most satisfactory is 1000 AM LST.

(2) Before the chart is changed, the correct relative humidity is obtained from the wet and dry bulb temperatures. The value is entered on the old chart where the trace ends, and on the new chart at the beginning of the trace.

(3) By the use of the pen arm release, raise the pen off the chart. Open the cover, remove the drum, and then remove the chart. The best practice is to place the used chart into a folder made of two blotters which dry and protect it. Wind the clock. Put on the new chart, making sure that it is tight, rests snugly on the shoulders of the

rum, and is correctly placed on the drum to have both ends under the pring clip and the right end over the left one. Replace the drum, naking the major adjustment for time. Ink the pen and then lower to within ⅛ inch of the chart. Make the relative humidity adjustnent, if necessary, followed by the minor adjustment for time. Close he cover and lower the pen to the chart. Make sure that the clock s running and that the pen is feeding ink properly.

d. Corrections.—The relative humidity value obtained from the wet nd dry bulb readings is more accurate and reliable than the value btained from the hygrograph trace. When the reading of the trace oes not agree with the relative humidity, the trace is corrected to nake it agree with the true value. The correct relative humidity alue is entered at the beginning and end of each trace. Unless there s a local need for relative humidity data from the hygrograph chart, o corrections will be applied to the trace. If any such data are equired, the following rules will be applied:

(1) The corrections will be placed above the chart in red ink.

(2) They will be appiled to the beginning and end of each trace, nd for each time the pen is touched.

(3) The correction will be accurate to the nearest whole percent.

(4) The correction will be prefixed by the proper symbol to indicate whether or not it is added to or subtracted from the trace reading to btain the correct relative humidity. If the relative humidity is 4 ercent greater than the hygrograph trace, then a +4 will be entered t that point above the trace. If the correction is zero, enter +0.

e. Incomplete records.—When the hygrograph fails to record a portion of the trace for the day, the gap in the trace will be filled in by nterpolation, if possible, and plainly marked as such. An explanatory ote will be entered on the record sheet giving the reason for the loss f record.

f. Incorrect time.—When the instrument is not running on correct ime, a note will be made on the sheet indicating the correct time or umber of minutes the clock is fast or slow at the time of observation. This fact will be considered in extracting data from the trace so that he correct time will be represented.

81. W. D., S. C. Form No. 201 (Pilot Balloon Ascension Report).—*a. General.*—Form No. 201 is used in recording and computing the wind aloft observations.

b. Disposition of completed Forms No. 201.—(1) Completed Forms No. 201 are kept in a special file among the permanent weather records of the weather station. They are kept in chronological order.

Form No. 201
Revised June 1, 19[illegible]

WAR DEPARTMENT
U. S. SIGNAL CORPS, METEOROLOGICAL SERVICE

PAGE ....

PILOT BALLOON ASCENSION REPORT

Station .... Date .... Starting time ....
Ascension number .... Number of theodolites used .... Time used ....th meridian

Observation point .... Altitude .... ft. | Observation point .... Altitude .... ft.

Minute.	Altitude. yds.	Elevation angle. °	Azimuth angle. °	Distance from observation point. yds.	Wind direction. 0—72	Wind speed. m. p. h.	Minute.	Altitude. yds.	Elevation angle. °	Azimuth angle. °	Distance from observation point. yds.	Wind direction. 0—72	Wind speed. m. p. h.
0	0			Zero setting on			0				Zero setting on		
1	240												
2	460												
3	680												
4	890												
5	1, 100												
6	1, 300												
7	1, 500												
8	1, 700												
9	1, 900												
10	2, 100												
11	2, 300												
12	2, 500												
13	2, 700												
14	2, 900												
15	3, 100												
16	3, 300												
17	3, 500												
18	3, 700												
19	3, 900												
20	4, 100												
21	4, 300												
22	4, 500												
23	4, 700												
24	4, 900												
25	5, 100												
26	5, 300												
27	5, 500												
28	5, 700												
29	5, 900												
30	6, 100												
31	6, 300												

Observer .... Base line .... yds. | Observer .... | Weight balloon .... gm.
Recorder .... Base line azimuth ....° | Recorder .... | Free lift .... gm.
Disappearance due to .... | Dis. due to .... | Total lift .... gm.

Clouds.	Amount.	Kind.	Dir.
Upper			
Lower			

Sun ....
Visibility ....
Temperature ....° F.
Pressure .... in.
Humidity ....%
Surface wind, direction ....
" velocity ....

Tables .... y. p. m.
T—A .... y. p. m.
Type of balloon ....
Type and serial number of theodolite ....
Notes ....

Computer .... Meteorologist in Charge.

U. S. GOVERNMENT PRINTING OFFICE [illegible] 8—[illegible]

FIGURE 160.—Form No. 201.

(2) Ascension reports of special significance are filed with the Form No. 1 for the month in which the observation was made and its location is indicated by a cross reference filed in its place in the file for Forms No. 201. The reason why the observation is considered especially significant must be indicated under "Notes" on each form filed with Form No. 1.

(3) Each month the reports of five ascensions whose durations are 10 minutes or greater are sent to the checking station designated by the regional control officer of the weather region in which the station is located. While these forms are not in the files, cross references are used to indicate that they are being checked. When the forms return to the station they are filed in the appropriate places.

c. *Method of making entries.*—Entries on Form No. 201 are made in pencil only. A 2H pencil or one of equal hardness should be used. The instructions below indicate the form of entry required in each blank of Form No. 201.

(1) *Page.*—The first page of each wind aloft observation is labeled 1; the second page is labeled 2, etc.

(2) *Station.*—Record the name and state of the station; for example, Chanute Field, Illinois.

(3) *Date.*—Herein record the month, the date of the month and the year.

(4) *Starting time.*—The starting time of observations is given to the nearest minute on the 24-hour clock, local standard time.

(5) *Ascension number.*—The number of each ascension is recorded in the space provided. The ascension number is one greater than the number for the previous ascension. The number is equal to the total number of observations taken.

(6) *Number of theodolites used.*—Give the number of theodolites used in making the run.

(7) *Time used.*—Record the meridian zone that corresponds with the local standard time.

(8) *Observation point.*—Record the designator of the point from which the observation was made, for example, if the station has two points A and B, and the theodolite was set on point B, record B in the space.

(9) *Altitude.*—Record the altitude above sea level of the station to the nearest foot.

(10) *0 minute.*—Here record the elevation angle and the azimuth of the reference point.

(11) *Zero setting on.*—Record, here, the compass point toward which

the oriented theodolite points when the horizontal circle reading is 0°.

(12) *Elevation angle.*—Enter in this column for each minute, the elevation angle to the nearest tenth of a degree observed at that minute.

(13) *Azimuth angle.*—Enter in this column for each minute the azimuth angle to the nearest tenth of a degree observed at that minute.

(14) *Distance from observation point.*—Enter, here, the horizontal distance of the pilot balloon from the observation point to the nearest 10 yards for each minute.

(15) *Wind direction.*—The wind direction for each minute is obtained from the plotting board and is recorded as obtained. The wind direction scale used must be indicated in the column heading, for example, 0–36 or 0–64.

(16) *Wind speed.*—The wind speed for each minute is obtained from the plotting board and is recorded to the nearest whole mile per hour.

(17) *Observer.*—The observer's grade and name are recorded here.

(18) *Recorder.*—The recorder's grade and name are recorded here.

(19) *Base line.*—In the event that two theodolites are used, the length of the base line between the two is recorded here.

(20) *Base line azimuth.*—If two theodolites are used in making the run, the azimuth of the base line is recorded to the nearest tenth of a degree.

(21) *Disappearance due to.*—Here record an explanation of why the run was discontinued; for example, entered low clouds, or smoke or similar notation.

(22) *Clouds.*—Record the amount, kind, and direction of all clouds. The amount is given in tenths coverage, the kind is given in the recognized literal abbreviations and the direction is given to eight points of the compass and recorded using the approved literal abbreviations. Upper clouds are recorded in the first two lines; middle clouds are recorded on the third and fourth lines; low clouds are recorded on the fifth and sixth lines.

(23) *Sun.*—Herein record the appearance of the sun. Example: bright, dull, etc.

(24) *Visibility.*—Record the visibility in miles and fractions thereof.

(25) *Temperature.*—Record the present temperature to the nearest tenth of a degree Fahrenheit.

(26) *Pressure.*—Record the sea-level pressure to the nearest hundredth of an inch.

(27) *Humidity.*—Record the relative humidity to the nearest whole percent.

(28) *Surface wind direction.*—The direction of the surface wind is

recorded on the same wind direction scale as is used for the winds aloft.

(29) *Surface wind speed.*—The speed of the surface wind is obtained and recorded to the nearest whole mile per hour.

(30) *Tables.*—When tables are used in computing the horizontal distance of the balloon, the standard rate of ascent for which the tables are computed is indicated here. The tables commonly used are for ascension rates of 200 yards per minute. When tables are not used, this fact is indicated by a dash (–).

(31) *T–A.*—No entry is made for **T–A.** This space is used in two theodolite observations.

(32) *Weight of balloon.*—Herein record to the nearest hundredth of an ounce the weight of the balloon (and lantern) used in the observation.

(33) *Free lift.*—Free lift is the resultant upward force on the balloon (and lantern) due to the balloon's being lighter than the air. It is recorded to the nearest hundredth of an ounce. It is 1.06 for the standard balloon with rate of ascent of 200 yards per minute.

(34) *Total lift.*—Total lift is the sum of the free lift and the weight of balloon (and lantern).

(35) *Type of balloon.*—Record the type number of the balloon used in making the run.

(36) *Type and serial number of theodolite.*—Record the type and serial number of the theodolite used; for example, ML 47C–13421.

(37) *Notes.*—Herein record any notes or remarks deemed necessary about the observation.

(38) *Computer.*—The person who computes the run records his grade and name here.

(39) *Meteorologist in charge.*—The grade or rank and name of the meteorologist in charge is recorded here.

(40) *Teletype report.*—At stations where the winds aloft are transmitted by code, the code message as transmitted is entered on the blank line before the last on Form No. 201.

(41) *Runs longer than 31 minutes.*—If the run lasts for more than 31 minutes, the general practice is to record the readings over 31 minutes in the right-hand column. In this case, the column under "Minute" is used to designate each minute by an appropriate number.

Section VI

RECORDING BASIC DATA ON SYNOPTIC WEATHER MAPS

82. General.—The surface synoptic map is plotted from the numeral weather codes received at 6-hourly intervals, on base map ML-86-B, or a similar type. In order to plot all information in an exact manner with an economy of space, and to include the maximum number of station reports on each map, it is necessary to employ symbols and coded entries to represent different elements of the report. The symbols used are in accord with those adopted internationally, with slight modifications. All entries must be made in black ink, as compactly as possible without affecting their legibility. An exact position for each entry will be designated, but a certain amount of latitude will be allowed when lack of space necessitates the modification of the station model. Generally, all data will be entered about a station circle in a square that has sides ½ inch long. This may readily be accomplished if individual entries are no more than 5/32 inch in length. Speed, without sacrifice of accuracy, is highly desirable. Development of speed is materially aided by: entering several items or elements each time reference is made to the data sheet; insisting upon the utmost compactness of entry consistent with legibility; selecting a convenient order of decoding and employing it consistently. The student, of course, will develop his own little "tricks of the trade" as proficiency is developed and there is but one exhaustive statement which can be made in this connection and that is that both speed and accuracy must be attained, for without either the value of the map produced will be materially reduced. The order in which the elements of the weather code are discussed in this section is a suggested order of decoding and map entry which, if followed, will lead to high proficiency. It will be noted that it follows closely the order in which the message is received.

Attention is called to the fact that in the tables and examples which occur in the following pages, all symbols, *except those representing directions*, are oriented with respect to the edges of the page exactly as they should be arranged with respect to the edges of a map. In the

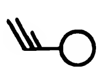
ase of all ***directions*** orientation should invariably be made with respect o the latitude and longitude of the place of entry.

83. Land station code.—*a. Position and coded entry of information bout the station circle.*

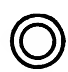
(1) *Station designator.*—The first three numbers of the Weather 'ode identify and locate the station at which the observation was ıade. Satisfactory speed in plotting will not be attained until the bserver knows accurately the station designator number and georaphical location of all reporting stations.

(2) *Wind direction.*—The wind direction is to be represented by an rrow flying with the wind with the head of the arrow shaft terminatıg at a point on the windward side of the circumference of the station ircle. The direction will be entered to 16 points of the compass as ıdicated on the 32-point scale, and will be placed as accurately as ıracticable when intercardinal points are decoded. The length of he shaft from the circumference of the station circle should be $\frac{3}{16}$ ıch.

(3) *Wind force.*—The wind force is indicated by barbs drawn at he end of the shaft away from the station circle, in a clockwise direcion from the shaft, sloping slightly backwards. Each barb represents wo points of the Beaufort Scale; an odd point is shown by a half barb. 'he half barb for wind forces of an odd Beaufort number greater than ıne will be entered on the station side of the group of full barbs. A ull barb should be $\frac{3}{16}$ inch in length, and a half barb $\frac{3}{32}$ inch. A calm s to be indicated by circumscribing the station circle in black ink. 'xamples of map entry for wind speed and direction are given below.



West wind—Beaufort Force 5.



Calm.

(4) *Sky coverage.*—The total amount of cloud is to be indicated by hading the station circle, as shown in table given below. Note that he map entry for code figures 1 and 2 is the same, as is the entry for ode figures 6 and 7.

Code figure	Tenths covered	Map entry	Code figure	Tenths covered	Map entry
0	None	○ (no entry)	5	7–8	◕
1	Few	⦶	6	9	⦶
2	1	⦶	7	Over 9 but less than 10.	⦶
3	2–3	◔	8	10	⦶
4	4–5–6	◑	9	Obscured	⊗

(5) *Visibility.*—The visibility limit is entered to the left and slightly above the station circle as a number or fraction. The entry is commonly accepted as the actual horizontal limit of visibility in miles or fraction of miles. However, it will be noticed from the table below that this is not strictly true, insofar as it actually represents a *range* of values, and the map entry coincides closely to the lowest applicable figure of the group of values it represents.

Code figure	Code limits	Map entry	Code figure	Code limits	Map entry
0	Less than 50 yd	0	5	1¼ to 2½ miles	1
1	50 yd. to ⅛ mile	0	6	2½ to 6 miles	2
2	⅛ to 5/16 mile	⅛	7	6 to 12 miles	6
3	5/16 to ⅝ mile	¼	8	12 to 30 miles	12
4	⅝ to 1¼ miles	½	9	Over 30 miles	30

Examle: ½○

(6) *Present weather.*—The weather prevailing at the time of observation is entered immediately to the left of the station circle, using the symbols given in the code table (see insert at back of manual). All entries of fogs, thunderstorms, dust or sandstorm, drifting snow, distant lightning, glaze, or signs of tropical hurricane *will be underlined with red pencil.* An example using the state of weather 62 would appear as follows: • • ○

(7) *Ceiling.*—The height of the ceiling is to be entered to the left of the station circle, directly below the "present weather" symbol. This entry is also commonly accepted as the actual height, in hundreds of feet, of the lowest height above the ground at which total cloudiness present covers more than five-tenths of the sky. This is not strictly true, but it does represent a range of values which, except in the case of code figure 1, coincides with the lowest applicable height, in hundreds of feet, of the group of values it represents.

Code figure	Ceiling height (feet)	Map entry	Code figure	Ceiling height (feet)	Map entry
0	Zero to 149	0	5	2,000 to 2,999	20
1	150 to 299	1	6	3,000 to 4,999	30
2	300 to 599	3	7	5,000 to 6,999	50
3	600 to 999	6	8	7,000 to 9,999	70
4	1,000 to 1,999	10	9	10,000 and over	U

Example: 10○

(8) *Temperature and dew point.*—These entries are made immediately to the right and a little above the station circle, just above the pressure entry. These are to be made in whole degrees Fahrenheit, and separated from one another by a slant (/) mark. The temperature will be entered to the left of the slant mark, and the dew point to the right.

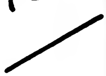
Example: ○58/52

(9) *Maximum and minimum temperatures* (optional).—The entries for these two values are to be entered to the right of the station circle, above the entry for barometric pressure and below the entries for temperature and dew point. The maximum temperature is the left-hand entry and will be separated from the minimum temperature by a slant (/) mark. A minus sign will be placed before temperature below zero. In messages reporting only one of these two values, a short dash will be placed in the space the missing value would normally occupy.

(10) *Barometric pressure.*—The corrected barometric pressure, reduced to sea level and coded in millibars and tenths of millibars, with the initial figure 9 or 10, representing "hundreds" of millibars, omitted, is entered immediately to the right of the station circle.

462750°—42——28

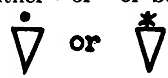
(11) *Barometric tendency and amount of pressure change within the past three hours.*—The barometric tendency of the past three hours is entered by the appropriate symbol given in the following table, immediately below the barometric pressure entry. The net amount of pressure change in the past three hours is entered just to the right of the symbol for barometric tendency, in one, two, or three figures, depending on the amount of change as sent in the code. The map entry will be made in tenths of millibars, and as the code element is for "fifths" of millibars, the conversion must be made by multiplying the code element by 2. The tendency symbols with positive slopes (sloping upward to the right) and negative slopes (sloping downward to the right) will indicate net increases or net decreases of pressure, respectively.

Code figure	Map entry	Code figure	Map entry	Code figure	Map entry
0		4		8	
1		5		9	
2		6			
3		7			

Example: 14

(12) *Amount of precipitation.*—The entry for amount of precipitation is entered on the map directly below the barometric tendency symbol. It will be entered on the map in hundredths of an inch, as coded. A trace of precipitation will be indicated by underlining the code figures 00, thus, <u>00</u>. When a thunderstorm without precipitation occurs, the amount is entered as 00.

(13) *Character of precipitation or thunderstorm.*—A symbol in accordance with the following table is to be entered to denote the character of precipitation or thunderstorm. It is placed immediately to the right of the entry for amount of precipitation.

Code figure	Type of precipitation or thunderstorm	Map entry
0	Character of precipitation unknown	U
1	Sleet or ice	△
2	Snow and rain mixed	
3	Intermittent (rain or snow)	Either • or * or both.
4	Showers (rain or snow)	
5	Drizzle	, ,
6	Rain (continuous)	• •
7	Snow (continuous)	* *
8	Thunderstorm with NO precipitation at station	
9	Thunderstorm WITH precipitation at station	

When either thunderstorm entry is made, it will be underlined with a red pencil.

(14) *Time thunderstorm began or time precipitation began or ended.*—The entry for this information is placed immediately to the right of and a little below the symbol denoting the character of precipitation or thunderstorm. The code figures actually represent an interval of time, but the map entry will be a time on the 24-hour clock, in the 75th meridian time belt, which will fall within the interval the code figure represents. The time entry will be computed according to the following table:

Code figure	Hours preceding time of observation	Map entry
0	Unknown, but less than 6 hours ago	
1	Less than 1	Map time plus 30 minutes less code figure.
2	From 1 to 2	Map time plus 30 minutes less code figure.
3	From 2 to 3	Map time plus 30 minutes less code figure.
4	From 3 to 4	Map time plus 30 minutes less code figure.
5	From 4 to 5	Map time plus 30 minutes less code figure.
6	From 5 to 6	Map time plus 30 minutes less code figure.
7	From 6 to 12	Map time plus 30 minutes less code figure.
8	From 12 to 18	Map time minus 30 minutes less 12.
9	More than 18	Map time less 30 minutes less 18.

(15) *Low clouds.*—The low cloud entry on the map is made immediately below the station circle by use of a symbol as given in the following table:

Code figure	Cloud type	Map entry
0	No lower clouds	(None made.)
1	Cumulus	
2	Swelling cumulus	
3	Cumulonimbus	
4	Stratocumulus formed by flattened cumulus	
5	Layer of stratus or stratocumulus	
6	Low broken clouds of bad weather (fractostratus or fractocumulus)	
7	Cumulus below stratocumulus	
8	Swelling cumulus below and penetrating stratocumulus	
9	Swelling cumulus or cumulonimbus with lower ragged clouds of bad weather	

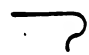
Example: 

(16) *Intermediate clouds.*—The middle clouds are to be entered directly above the station circle by appropriate symbol given in the following table:

Code figure	Cloud type	Map entry
0	No intermediate clouds	(None made.)
1	Altostratus	
2	Nimbostratus	
3	Altocumulus	
4	Patches of altocumulus	
5	Parallel bands of altocumulus	
6	Altocumulus formed by spreading cumulus	
7	Altocumulus associated with altostratus	
8	Altocumulus castellatus	
9	Complex altocumulus in several layers	

Example: 

(17) *High clouds.*—The upper clouds are to be entered directly over the intermediate cloud symbol. If no intermediate clouds were reported, the high clouds will be entered directly above the station circle. The entry will be made by using the appropriate symbol given in table below:

Code figure	Cloud type	Map entry
0	No high clouds	(None made.)
1	Cirrus	
2	Abundant cirrus	
3	Cirrus originating in cumulonimbus	
4	Cirrus in tufts or hooks	
5	Bands of cirrus or cirrostratus not more than 45° above horizon	
6	Bands of cirrus or cirrostratus more than 45° above horizon	
7	Cirrostratus covering entire sky	
8	Cirrostratus, not increasing in amount, and not covering entire sky	
9	Cirrocumulus, with small amount of cirrus	

Example: 

(18) *Direction of clouds.*—The direction from which clouds are moving is sent in the code to eight cardinal points of the compass, and is applicable to the group of intermediate clouds whenever observed, for high clouds when no intermediate type is observed but high types are present, or for low cloud types whenever they are the only form

observed. The cloud direction is entered on the map as a short arrow flying in the same direction as the cloud is moving, entered to the right of the cloud symbol.

Code figure	Cloud direction	Map entry	Code figure	Cloud direction	Map entry
0	Calm or variable	C	5	SW	↗
1	NE	↙	6	W	→
2	E	←	7	NW	↘
3	SE	↖	8	N	↓
4	S	↑	9	Unknown	U

Example: 

(19) *Direction and force of maximum wind* (optional).—This information is sent only when the highest 1-minute velocity during 6 hours preceding the observation exceeds 38 miles per hour, or equals or exceeds the specified verifying velocity of a station. The map entry is made by symbol, arrow and barbs, as explained for current wind conditions, (2) and (3) above, placed immediately below the entry indicating lower clouds.

(20) *Depth of snow on ground* (optional).—The entry is made to denote a range of values, but will be the numeral representing the maximum value in the range it represents. It is to be placed below the entry for maximum wind direction and force, or below the lower cloud entry.

Code figure	Depth of snow on ground (inches)	Map entry	Code figure	Depth of snow on ground (inches)	Map entry
0	Trace to 0.9	1	5	9.0 to 14.9	15
1	1.0 to 2.9	3	6	15.0 to 20.9	21
2	3.0 to 4.9	5	7	21.0 to 26.9	27
3	5.0 to 6.9	7	8	27.0 to 32.9	33
4	7.0 to 8.9	9	9	33.0 or more	33+

(21) *Pressure at 5,000 feet above sea level.*—In plotting the map for certain areas, it is desirable to enter the pressure for the 5,000-foot plane above sea level, which is only sent by stations having an elevation of 3,000 feet or more. This entry is entered immediately below the amount, type, and time of precipitation entry, and is entered in millibars and tenths of millibars with the initial figure, representing "hundreds," omitted. The usual range of the pressure at the 5,000-foot level is between 800.0 mb and 900 mb.

(22) *Baromteric tendency during the 3-hour period ending 3 hours preceding the time of observation* (optional).—The entry for this information is made immediately to the right of the pressure entry at the 5,000-foot level above sea level, in accordance with the same table of symbols given in (11) above.

b. A complete report is listed below, with the proper map entry and grouping about the station circle. It is drawn to a larger scale than the one used on the base map.

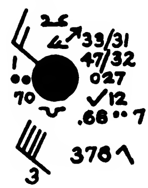
Time of observation: 0730 EST.

Coded message: 27685 28362 02733 31406 52785 66166 73789 82845 32147.

Code element	Reference	Map entry
276	Station designator for Mogollon, N. M	
283	NW. wind, Force 3	
8	10 tenths sky coverage	
5	Visibility 1¼ to 2½ miles	1
62	Continuous light rain	• •
8	Ceiling 7,000 to 9,999 feet	70
027	Barometric pressure 1002.7 mb	027
33	Temperature 33° F	33
31	Dew point 31° F	31
4	Barograph was falling, but is now rising, showing a plus change for past 3 hours	
06	Pressure has changed 1.2 mb in past 3 hours	12
5	Low clouds, stratus or stratocumulus	
2	Intermediate clouds, thick altostratus	
7	High clouds, cirrostratus	
5	Middle clouds coming from SW	

Code element	Reference	Map entry
66	Amount of precipitation 0.66 inch	66
6	Character of precipitation, continuous rain	••
1	Precipitation started less than 1 hour ago	7
378	Pressure at 5,000 feet, 837.8 mb	378
9	Barometer was steady, then falling 3 to 6 hours ago	
2845	NW. wind of 45 miles per hour (Beaufort force 8) was maximum wind direction and speed	
47	Maximum temperature 47° F	47
32	Minimum temperature 32° F	32
1	1.0 to 2.9 inches of snow on ground	3

Station model



84. Code for observations made by ships at sea.—*a. Position and coded entry of information about position of ship contained in Universal Data.*—(1) *Day.*—The day of the week is used by the plotter to check the fact that the code is applicable to the current map being plotted.

(2) *Octant.*—The octant of the globe in which the ship is situated will assist the plotter in locating the ship's position.

(3) *Position.*—By using the latitude and longitude, the exact position of the ship will be determined, and indicated on the base map by a small circle about ⅛ inch in diameter. Whenever available, it is important to verify the position of the ship by reference to the position reported in the previous observation.

(4) *Time.*—The coded time of the observation is used by the plotter to check the message as applicable to the map being plotted.

(5) *Wind.*—The wind direction and force is indicated in the same manner as for land station reports.

(*a*) When the coded wind direction has been increased by 33, which indicates *unusual gustiness*, a small **v** is placed along the shaft of the wind arrow on the side opposite the barbs.

(*b*) When the coded wind direction has been increased by 67, which indicates a *definite squall* or *line squall* during the past hour, the squall symbol (Λ)—symbol 14, is placed in the position for past weather.

(6) *Present weather.*—This entry is made by using the same symbols that land stations have, in the same position about the circle indicating the ship's position.

(7) *Barometric pressure.*—This entry is made in the same position and manner as for land stations. As the code gives the pressure to whole millibars, excluding "tenths" of millibars, the figure 0 will be added to the coded figures for map entry.

Code	Barometric pressure	Map entry
66	966.0 mbs	660

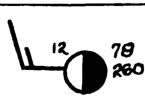
(8) *Visibility.*—The map entry for visibility is made using the same code given in paragraph 83*a*(5), and same position about the station circle as for land stations.

(9) *Temperature.*—The air temperature in °F is entered in the same manner and position about the station circle as for land station reports.

(10) The example given here illustrates the correct position for entry of each element of the message contained in groups of the Universal Data:

20305 69712 24301 26878

Code figure	Reference	Map entry
2	Monday is the day of the week observation was made	
0	In octant of globe located in Northern Hemisphere, between 0° W. and 90° W. longitude	
305	Ship's position was at 30.5° N. latitude	
697	Ship's position was at 69.7° W. longitude	
12	Time of observation 1200 GMT	
243	Wind direction, West—Beaufort Force 3	
01	Partly cloudy (from exactly 0.1 to exactly 0.5)	
26	Barometric pressure 1026.0 mbs	260
8	Visibility limit 12 to 30 miles	12
78	Air temperature 78° F	78



b. Position and coded entry of information about the position of the ship contained in a message having the Universal Data plus Supple-

mental Three Data.—The first four groups of five figures each are decoded and entered on the map about the station circle, as described in *a*(10) above.

(1) *Low clouds.*—The entry for low clouds is made in the same position about the station circle, using the same symbols, as for land station reports. See paragraph 83*a*(15).

(2) *Intermediate clouds.*—Same as for land stations. See paragraph 83*a*(16).

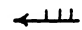
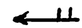
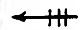
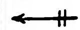
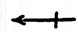
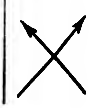
(3) *High clouds.*—Same as for land stations. See paragraph 83*a* (17).

(4) *Sky coverage.*—Same as for land stations. See paragraph 83*a* (4).

(5) *Sea temperature.*—The map entry of the surface temperature of the sea is made in ° F., just to the right of the air temperature, and is separated therefrom by a slant (/) mark. It is in the same relative position as that occupied by the dew point for the land station reports. The code figure for sea temperature represents a number of degrees of difference from the air temperature. From this the sea temperature will be calculated as shown by the following table:

Code figure	Air temperature (Fahrenheit)	Add algebraically to air temperature	Code figure	Air temperature (Fahrenheit)	Add algebraically to air temperature
0	9° or more higher than sea temperature	−9	6	1° to 3° lower than sea temperature	+2
1	6° to 9° higher than sea temperature	−7	7	3° to 6° lower than sea temperature	+4
2	3° to 6° higher than sea temperature	−4	8	6° to 9° lower than sea temperature	+7
3	1° to 3° higher than sea temperature	−2	9	More than 9° lower than sea temperature	+9
4	Same as sea temperature	0			
5	Less than 1° lower than sea temperature	+1			

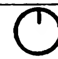
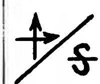
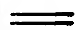
(6) *Swell in open sea and direction from which sea swell is coming* (optional).—This entry on the map is made by use of the appropriate symbol, shown in following table, which is so orientated that it shows the direction to which the swell is moving. The table giving the direction code follows the table of symbols for sea swells of varying magnitude. The entry should be placed immediately below that for the "past weather."

Code figure	Description	Map entry
0	No swell	(None.)
1	Low swell, short or average length	
2	Low swell, long	
3	Moderate swell, short	
4	Moderate swell, average length	
5	Moderate swell, long	
6	Heavy swell, short	
7	Heavy swell, average length	
8	Heavy swell, long	
9	Confused swell	

Code figure	Direction from which swell is coming	Code figure	Direction from which swell is coming
0	No swell.	5	SW.
1	NE.	6	W.
2	E.	7	NW.
3	SE.	8	N.
4	S.	9	No observation or information.

NOTE.—Be sure to enter symbol for sea swell so it indicates direction toward which the sea swell is moving.

(7) *Past weather.*—The map entry for past weather is a symbol, as shown in following table, placed directly under the barometric tendency and amount of pressure change.

Code figure	Description	Map entry
0	Fair (clear or slightly clouded)	
1	Variable sky	
2	Mainly overcast	
3	Sandstorm, duststorm, or drifting snow	
4	Fog or thick dust haze (visibility less than 1,100 yards)	
5	Drizzle	
6	Rain	
7	Snow or sleet	
8	Showers	
9	Thunderstorm	

When code figures 3, 4, or 9 are sent, the symbol will be underlined with a red pencil.

(8) *Amount of low cloud.*—The entry for amount of low clouds is entered, as a number representing tenths of sky covered, immediately to the right of the symbol for low clouds. It represents the highest applicable figure of the International Code, as given in the following table:

Code figure	Amount of sky covered	Map entry	Code figure	Amount of sky covered	Map entry
0	0.0	(None)	6	0.9	9
1	Less than 0.1	1–	7	More than 0.9, with breaks	9+
2	0.1	1	8	Sky completely covered	10
3	0.2 to 0.3, inclusive	3	9	Sky obscured	(None)
4	0.4 to 0.6 inclusive	6			
5	0.7 to 0.8 inclusive	8			

Example: 

(9) *Ship direction.*—The direction toward which the ship is moving is indicated by an arrow originating at the station circle and pointing in the direction of the ship's course. The direction is determined by use of the following table:

Code figure	True direction	Map entry	Code figure	True direction	Map entry
0	Ship hove to	(None)	6	W	←
1	NE	↗	7	NW	↖
2	E	→	8	N	↑
3	SE	↘	9	No observation or information	(None)
4	S	↓			
5	SW	↙			

(10) *Ship speed.*—The map entry is a numeral entered near the head of the arrow which indicates the ship direction. It is a code figure representing a range of values in knots, and is the lowest value of the group it represents, as shown in following table:

Code figure	Ship speed (knots)	Map entry	Code figure	Ship speed (knots)	Map entry
0	Ship stopped	0	5	13 to 15	13
1	1 to 3	1	6	16 to 18	16
2	4 to 6	4	7	19 to 21	19
3	7 to 9	7	8	22 to 24	22
4	10 to 12	10	9	More than 24	25

NOTE.—An arithmetical means of computing the map entry is to multiply the code figure by 3 and subtract 2 from the product.

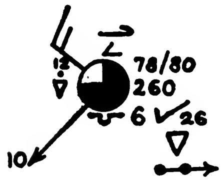
(11) *Barometric tendency and amount of pressure change for past 3 hours.*—The map entries for these two code elements are made in the same manner and position about the station circle as for land stations. See paragraph 83*a*(11).

A station model is given below, with the coded message, which illustrates the correct entry and the position for each code element.

30305 69712 28381 26878 35115 61684 54413

Code element	Reference	Map entry
3	Day of week—Tuesday	--------
0	In octant of globe in Northern Hemisphere, between 0° W. and 90° W. long	--------
305	Ship's position 30.5° N. lat	--------
697	Ship's position 69.7° W. long	--------
12	Time of observation 1200 GMT	
283	Wind direction NW.—Beaufort Force 3	
81	Moderate rain showers	
26	Barometric pressure 1026.0 mb	260
8	Visibility limit 12 to 30 miles	12
78	Air temperature 78° F	78
5	Layer of stratus or stratocumulus	
1	Altostratus	
1	Cirrus	
5	Sky coverage 7 to 8 tenths	
6	Air temperature 1° to 3° lower than sea temperature	80 (for sea temperature).
16	Low sea swell of average length, coming from the west	
8	Past weather, showers	
4	From 0.4 to 0.6 low clouds	6
5	Ship moving toward SW	↙
4	Ship speed from 10 to 12 knots	10
413	Barometer was falling, now rising, within past 3 hours, and shows a plus change of 2.6 mb	✓26

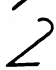
Station model



c. Position and coded entry of information about the position of the ship contained in a message having the Universal Data plus Supplemental Six Data.—The Universal Data, contained in the first four groups of five figures each, are decoded and entered on the map as described in *a*(10) above.

(1) *Swell in open sea and direction from which sea swell is coming* (optional).—These elements are entered on the map about the station circle the same as when sent in Supplemental Three Data. See *b*(6) above.

(2) *Form of predominating cloud.*—The map entry for form of predominating cloud is a symbol placed directly below station circle. This symbol is taken from the International Cloud Types, as shown in accompanying table. When sky is clear, a slant (/) mark is sent as the code element.

Code figure	Description	Map entry	Code figure	Description	Map entry
0	Stratus or fractostratus		5	Altostratus	
1	Cirrus		6	Stratocumulus	
2	Cirrostratus		7	Nimbostratus	
3	Cirrocumulus		8	Cumulus or fractocumulus	
4	Altocumulus		9	Cumulonimbus	

Example: 

(3) *Amount of sky coverage.*—This map entry is the same as for Supplemental Three Group. See *b*(4) above.

(4) *Sea temperature.*—This map entry is the same as for Supplemental Three Group. See *b*(5) above.

(5) *Ship direction.*—This map entry is the same as for Supplemental Three Group. See *b*(9) above.

(6) *Amount and characteristic of barometric tendency.*—The map entry is made directly beneath the barometric pressure entry, and is taken from the following table:

Code figure	Amount and characteristic of barometric tendency	Map entry
0	Steady (has not fallen or risen more than 0.01 inch or 0.5 mb in last 3 hours).	∧5
1	Rising slowly (has risen 0.03 to 0.04 inch or 1.0 to 1.5 mb in last 3 hours).	/10
2	Rising (has risen 0.06 to 0.10 inch or 2.0 to 3.5 mb in last 3 hours).	/20
3	Rising quickly (has risen 0.12 to 0.18 inch or 4.0 to 6.0 mb in last 3 hours).	/40
4	Rising very rapidly (has risen more than 0.18 inch or 6.0 mb in last 3 hours).	/60
5	Falling slowly (has fallen 0.03 to 0.04 inch or 1.0 to 1.5 mb in last 3 hours).	\10
6	Falling (has fallen 0.06 to 0.10 inch or 2.0 to 3.5 mb in last 3 hours).	\20
7	Falling quickly (has fallen 0.12 to 0.18 inch or 4.0 to 6.0 mb in last 3 hours).	\40
8	Falling very rapidly (has fallen more than 0.18 inch or 6.0 mb in last 3 hours).	\60

(7) *Past weather.*—This map entry is the same as for Supplemental Three Group. See *b*(8) above.

(8) *High cloud.*—This entry is placed immediately above the station circle, using symbols given for land station ontries. See paragraph 83*a*(17).

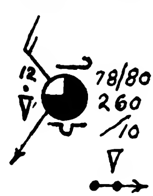
(9) A station model is given below, with the coded message, which illustrates the correct entry and position for each code element.

20305 69712 28381 26878 61665 65181

Code figure	Reference	Map entry
2	Day of week—Monday	
0	Octant of globe in Northern Hemisphere, between 0° W. and 90° W. long.	
305	Ship's position 30.5° N. lat	
697	Ship's position 69.7° W. long	
12	Time of observation 1200 GMT	
283	NW. wind Beaufort Force 3	
81	Moderate rain showers	
26	Barometric pressure 1026.0 mb	260
8	Visibility 12 to 30 miles	12
78	Air temperature 78° F	78
16	Low sea swell of average length, coming from the west	
6	Stratocumulus type clouds predominate	
5	Sky coverage 7 to 8 tenths	
6	Air temperature 1° to 3° F. lower than sea temperature	[1] 80
5	Ship moving toward SW	
1	Barometer rising slowly (has risen 1.0 to 1.5 mb in past 3 hours)	/10
8	Past weather, showers	
1	Type of high clouds, cirrus	

[1] For sea temperature.

Station model



d. Position and coded entry of information about the position of the ship contained in a message having the Universal Data plus Supplemental Nine Data.— The Universal Data are contained in first four groups of five figures each, and are decoded and entered on the map as described in *a*(10) above.

(1) *State of the sea* (optional).—This map entry is made by a numeral to the right of the symbol indicating the sea swell and direction of sea swell. It actually represents a range in the amplitudes of waves, and the entry is the maximum value of the group it represents.

Code figure	Description and height of wave, crest to trough (feet)	Map entry	Code figure	Description and height of wave, crest to trough (feet)	Map entry
0	Calm, 0	0	5	Very rough, 8 to 12	12
1	Smooth, less than 1	1	6	High, 12 to 20	20
2	Slight, 1 to 3	3	7	Very high, 20 to 40	40
3	Moderate, 3 to 5	5	8	Precipitous, over 40	40+
4	Rough, 5 to 8	8	9	Confused	?

(2) *Swell in open sea* and *direction from which sea swell is coming* (optional).—These elements are entered on the base map about the station circle, the same as when sent in Supplemental Three Data. See *b*(6) above.

(3) *Past weather*.—This map entry is the same as for Supplemental Three Data. See *b*(7) above.

(4) *Form of predominating cloud*.—This map entry is the same as for Supplemental Six Data. See *c*(2) above.

(5) *Sky coverage*.—This map entry is the same as for Supplemental Three Data. See *b*(4) above.

(6) *Amount of low clouds*.—This map entry is the same as for Supplemental Three Data. See *b*(8) above.

(7) *Amount and characteristic of barometric tendency*.—This map entry is the same as for Supplemental Six Data. See *c*(6) above.

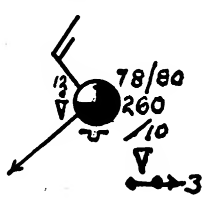
(8) *Sea temperature*.—This map entry is the same as for Supplemental Three Data. See *b*(5) above.

(9) A station model is given below, with the coded message, which illustrates the correct entry and position for each code element.

20305 69712 28381 26878 92168 65416

Code figure	Reference	Map entry
2	Day of week—Monday	
0	Octant of globe in Northern Hemisphere, between 0° W. and 90° W. long	
305	Ship's position 30.5° N. lat	
697	Ship's position 69.7° W. long	
12	Time of observation 1200 GMT	
283	NW. wind—Beaufort Force 3	
81	Moderate rain showers	
26	Barometric pressure 1026.0 mb	260
8	Visibility 12 to 30 miles	12
78	Air temperature 78° F	78
2	Waves from 1 to 3 feet	3
16	Low sea swell of average length, coming from the west	
8	Past weather, showers	
6	Stratocumulus type clouds predominate	
5	Sky coverage 7 to 8 tenths	
4	From 0.4 to 0.6 low clouds	6
1	Barometer rising slowly (has risen 1.0 to 1.5 mb in past 3 hours)	/10
6	Air temperature 1° to 3° F. lower than sea temperature	80 (sea temp.)

Station model



85. Mexican land station code.—*a. General.*—The reporting stations in Mexico use a code that varies slightly, depending on the time of the report. These reports are gathered at a station in the United States, usually Brownsville, Texas, and the information relayed to United States stations over the teletype in a code of five groups of five figures each. Whether it is this code, or one of the complete Mexican codes, the information contained in the relayed code will be that plotted about the station circle in conformity with the following instructions.

b. Position and coded entry of information about the station circle.—(1) *Station designator.*—This will identify and locate the position of the reporting station.

(2) *Wind direction and wind force.*—These entries are made about the station circle employing the same means as for land station code. See paragraph 83*a*(2) and (3).

(3) *Sky coverage.*—This entry is made by shading the station circle exactly as for the land station code. See paragraph 83*a*(4).

(4) *Visibility.*—This entry is made by employing the same methods as for land station code. See paragraph 83*a*(5).

(5) *Present weather.*—This entry is made by use of the same symbols and in the same position about the station circle as for land station code. See paragraph 83*a*(6).

(6) *Barometric pressure.*—This entry is made in the same manner as for the land station code. See paragraph 83*a*(10).

(7) *Temperature.*—This entry is made in the same manner as for the land station code. See paragraph 83*a*(8).

(8) *Pressure at 5,000 feet above sea level.*—This entry, which is coded in the same manner as for land station code, will be entered directly below the amount of precipitation, described in (14), below. The entry will consist of three figures, representing millibars and tenths of millibars, with the initial figure representing "hundreds" omitted.

(9) *Low, intermediate, and upper clouds.*—Entered on the map about the station circle employing the same symbols and in the same position as for land station code. See paragraph 83*a*(15), (16), and (17).

(10) *Direction of clouds.*—This entry is made by employing the same means as for land station code. See paragraph 83*a*(18).

(11) *Amount of precipitation.*—This entry will be made directly below the barometric pressure entry, in inches and hundredths of inches. It will be necessary to convert the coded information, which is in millimeters, by use of conversion tables, or by dividing the coded value by 25.4.

c. A report is listed below.

16985 28362 02753 90852 75017

Code element	Reference	Map entry
169	Station designator for Monclova, Coah	
283	NW. wind, Beaufort Force 3	
8	10 tenths sky coverage	●
5	Visibility 1¼ to 2½ miles	1
62	Continuous light rain	••
027	Barometric pressure 1002.7 mb	027
53	Temperature 53° F	53
908	Pressure at 5,000 feet 890.8 mb	908
5	Low clouds, stratus or stratocumulus	
2	Intermediate clouds, thick altostratus	
7	High clouds, cirrostratus	
5	Middle clouds coming from SW	
017	17 mm of precipitation in last period. Equivalent amount is 0.66 inch	.66

86. Code for Caribbean weather stations.—*a. General.*—There are an increasing number of stations in the Caribbean area that now transmit their reports which are encoded using the land station code. The plotter will be able to determine by inspection whether the land station code or the Caribbean weather station code, described in this paragraph, is being used, and to decode the information accordingly.

b. Position and coded entry of information about the station circle.—(1) *Station designator.*—This code element is used to identify and locate the station at which the observation was made.

(2) *Wind direction and wind force.*—This entry is made about the station circle the same as for land station code. See paragraph 83*a*(2) and (3). It will be noted, however, that the wind direction is sent to 8 points of the compass.

(3) *Present weather.*—This entry is made exactly as for the land station code. See paragraph 83*a*(6).

(4) *Barometric pressure.*—This entry is made immediately to the right of the station circle, using the same means employed in plotting the code for ships at sea. See paragraph 84*a*(7).

(5) *Temperature.*—This entry is made exactly as for the land station code. See paragraph 83*a*(8).

(6) *Form of predominating cloud.*—This entry is made in exactly the same manner as for the Supplemental Six Group of ships at sea. See paragraph 84*c*(2).

(7) *Direction of predominating cloud.*—The direction of the predominating cloud is indicated in exactly the same manner as for land station code. See paragraph 83*a*(18).

(8) *Ceiling.*—This entry is made the same as for land station code. See paragraph 83*a*(7).

(9) *Sky coverage.*—This entry is made by shading the station circle, as described for land station code. See paragraph 83*a*(4).

(10) *Visibility.*—The entry for horizontal visibility is made in the same manner as for land station code. See paragraph 83*a*(5).

c. A report is listed below.

15257 51275 86659

Code element	Reference	Map entry
015	Station designator for San Juan, Puerto Rico	
75	NW. wind, Beaufort Force 5	
25	Rain showers occurred within past hour	
12	Barometric pressure 1012.0 mb.	120
75	Temperature 75° F	75
8	Predominating cloud cumulus	
6	Cumulus coming from west	
6	Ceiling from 3,000 to 4,999 feet	
5	Sky from 7 to 8 tenths covered	
9	Visibility over 30 miles	

Section VII

PLOTTING AUXILIARY CHARTS

87. Wind-aloft chart.—*a. Purpose.*—The purpose of this chart is to depict in a clear and concise manner the wind velocities at the surface of the earth and at other horizontal planes at established intervals above mean sea level. Supplemental to these data, the pressure fields for the 5,000-, 10,000-, 15,000-, and 20,000-foot planes above sea level will also be depicted on this map. The data for this map are gathered simultaneously at a number of stations at strategic locations in continental United States and disseminated over the teletype in coded form. The codes containing the wind velocity and pressure data are described in section IV. The map will have an immediate utility in furnishing a pilot with information directly affecting his choice of flying altitude. A further function of the chart is to furnish the forecaster a visual aid in determining the horizontal flow patterns of the atmosphere at different levels. These are of material assistance in preparing a solution of the synoptic map and the formulation of the forecast. The pressure fields drawn for the 5,000-, 10,000-, 15,000-, and 20,000-foot planes are also of material assistance, both for interpolating for wind velocities at nonreporting stations and in preparation of the forecast.

b. Description.—Map ML–108–A (fig. 161) is used for the preparation of the wind-aloft map.
Each of the nine sections of this map has an outline map of the United States, with state boundaries indicated. A number of representative stations are indicated by a small circle of ⅛-inch diameter, with the numeral code designator placed directly to the left of each circle. It will be noted that the section in the upper left-hand corner is reserved for entry of the surface data. Moving progressively to the right in the top row, the data for the surface, 2,000-foot level and 4,000-foot level will be entered in the appropriately labeled sections. The second row of sections, starting with the left-hand section, and

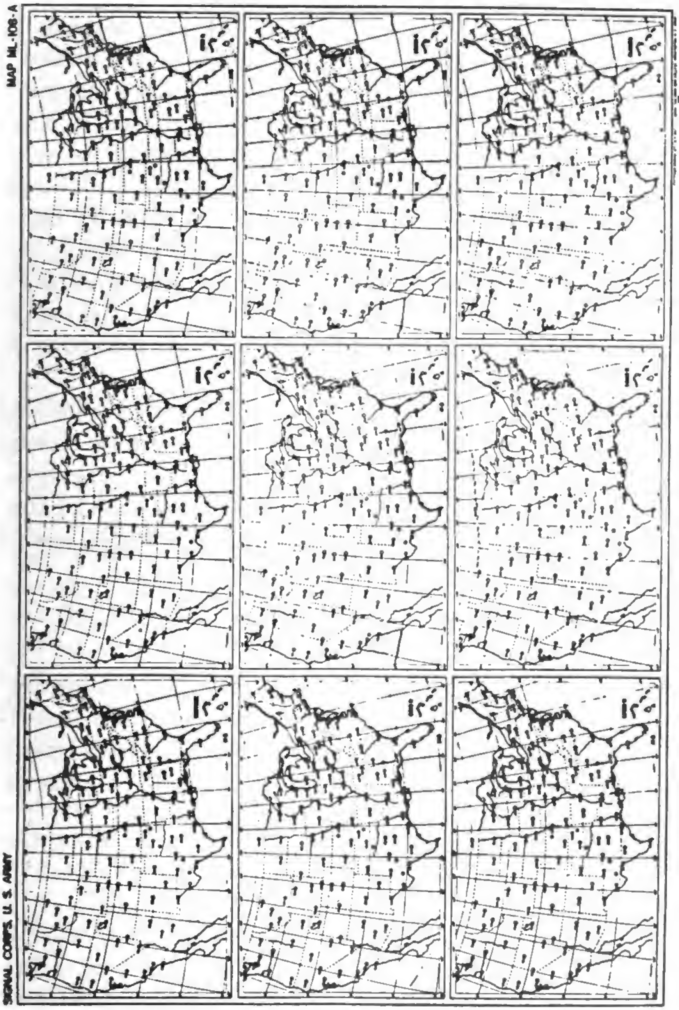
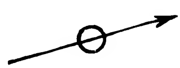


FIGURE 161.—Wind-aloft chart ML-108-A.

moving progressively to the right, will be used for entering the 6,000-, 8,000-, and 10,000-foot data. The lowest row of sections will be reserved for the entry of the 12,000-, 14,000-, and 20,000-foot data going from the left to right as labeled. The lowest right-hand section, labelled "clouds," will be used for the entry of the data of the 20,000-foot plane. The pressure entries and isobars for the 5,000-foot level will be entered in the left-hand section of the middle row, on which the 6,000-foot level wind velocities are entered. The 10,000-foot pressure entries and isobars will be placed in the right-hand section of the middle row, labeled "10,000 feet," in which the wind velocities for the 10.000-foot plane are entered. The pressure entries and isobars for the 15,000-foot plane are made in the middle section of the lowest row, labeled "14,000 foot," in which the wind velocities for the 14,000-foot level are entered. The pressure entries and isobars for the 20,000-foot plane will be placed in the lower right-hand section, labeled "clouds," in which wind velocities for the 20,000-foot plane have been placed.

c. *Method of entry.*—(1) The wind direction will be indicated at each significant level to be plotted by an arrow drawn through the center of the station circle for which the data are intended. The arrow will be drawn as flying with the wind. The shaft of the arrow will be ¾ inch in length, with equal segments extending on each side of the station circle, as indicated below:



When no station circle is printed on the map for the station for which data are available, the arrow will be placed so that the center of the shaft will mark the position of the station. To facilitate speed, these arrows will be drawn free hand. The arrows will be entered to 16 points, as indicated in the following direction table:

Code figure	Direction in degrees	Direction of arrow	Code figure	Direction in degrees	Direction of arrow
01	6–14	N.	19	186–194	S.
02	15–25	NNE.	20	195–205	SSW.
03	26–34	NNE.	21	206–214	SSW.
04	35–45	NE.	22	215–225	SW.
05	46–54	NE.	23	226–234	SW.
06	55–65	ENE.	24	235–245	WSW.
07	66–74	ENE.	25	246–254	WSW.
08	75–85	E.	26	255–265	W.
09	86–94	E.	27	266–274	W.
10	95–105	E.	28	275–285	W.
11	106–114	ESE.	29	286–294	WNW.
12	115–125	ESE.	30	295–305	WNW.
13	126–134	SE.	31	306–314	NW.
14	135–145	SE.	32	315–325	NW.
15	146–154	SSE.	33	326–334	NNW.
16	155–165	SSE.	34	335–345	NNW.
17	166–174	S.	35	346–354	N.
18	175–185	S.	36	355–5	N.

(2) Arrows representing the wind directions, starting with west and proceeding clockwise through east northeast, will be drawn in with blue pencil or black ink. All other wind directions will be shown with red pencil or red ink. Wind speed entries will be made in the same color as that used for the arrow.

(3) The wind speed will be entered by numerals which will show the speed in miles per hour. When the arrows indicate directions of WNW., W., WSW., ESE., E., or ENE., the entry will be made directly above the station circle or directly above the middle of the arrow shaft. For all other indicated wind directions the speed entry will be made immediately to the right of the station circle or directly to the right of the middle of the arrow shaft. The same relative positions will be maintained at reporting stations for which there is no circle on the map.

(4) A "calm" condition will be indicated by the letter "C" drawn about the station circle with blue pencil or black ink.

(5) No entry will be made at any station failing to obtain an observation.

(6) Pressure values in whole millibars for the 5,000-, 10,000-, 15,000-, and 20,000-foot planes will be entered in blue pencil or black ink immediately to the left of the station circle. When the wind direction arrow would interfere with this position, such as that indicating a wind

from the WNW., W., WSW., ENE., NE., or ESE., the entry will be lowered slightly so that its legibility will not be affected.

(7) Isobars for all pressure values evenly divisible by three will be drawn for the planes for which entries are made, 5,000, 10,000, 15,000, and 20,000 feet. These will be drawn smoothly with black pencil, and need not be labeled with a pressure value.

88. Adiabatic chart.—*a. Purpose.*—The adiabatic chart is used to depict the vertical temperature distribution of the atmosphere above a selected station and to indicate thereby the degree of stability or instability of the air mass in which the sounding was made. By plotting a curve in which we use the observed temperatures at different levels as the abscissas and the pressure values as ordinates for successive points, we will have a graphic representation of the vertical temperature gradient, or existing lapse rate. Discontinuities in the lapse rate are readily discernible and the correct analysis of their causes will lead to an accurate and complete understanding of various processes which are operative. Aerological soundings determine the values of temperature, pressure, and relative humidity existing at different levels above certain selected stations located within the United States. By making simultaneous soundings at these stations, a composite picture of the structure of the atmosphere will be obtained which enables the forecaster to explain current meteorological phenomena and accurately depict future changes. Adiabatic curves, plotted from the data derived from these soundings, will show at a glance the degree of stability of the atmosphere, the level at which air mass discontinuities occur, and the position of subsidence inversions. The correct analysis of the curve in regard to the air mass classification will also be of material assistance in determining the position of a frontal discontinuity on the surface synoptic map.

b. Description.—The adiabatic curve is plotted on either chart ML–123 or chart ML–124. As they have certain basic differences, and since supplemental data of different nature can be deduced from each chart, it is necessary to consider each separately.

(1) *Chart ML–123.*—The adiabatic chart ML–123 is shown in figure 162.
The abscissae are temperatures in degrees centigrade, and the ordinates are pressures in millibars, spaced on a logarithmic scale. Solid lines sloping upward from right to left are lines of constant potential temperature, commonly known as "dry adiabats." Supplemental data may be obtained by use of the broken lines sloping upward from left to right, which represent values of specific humidity in grams of

water vapor per kilogram of air. Vapor pressure values in millibars are also represented by the abscissae on the right of the chart, the values being labeled along the upper right horizontal border of the grid. On each ordinate representing an exact hundred millibar pressure value are a series of short vertical lines. These are used in

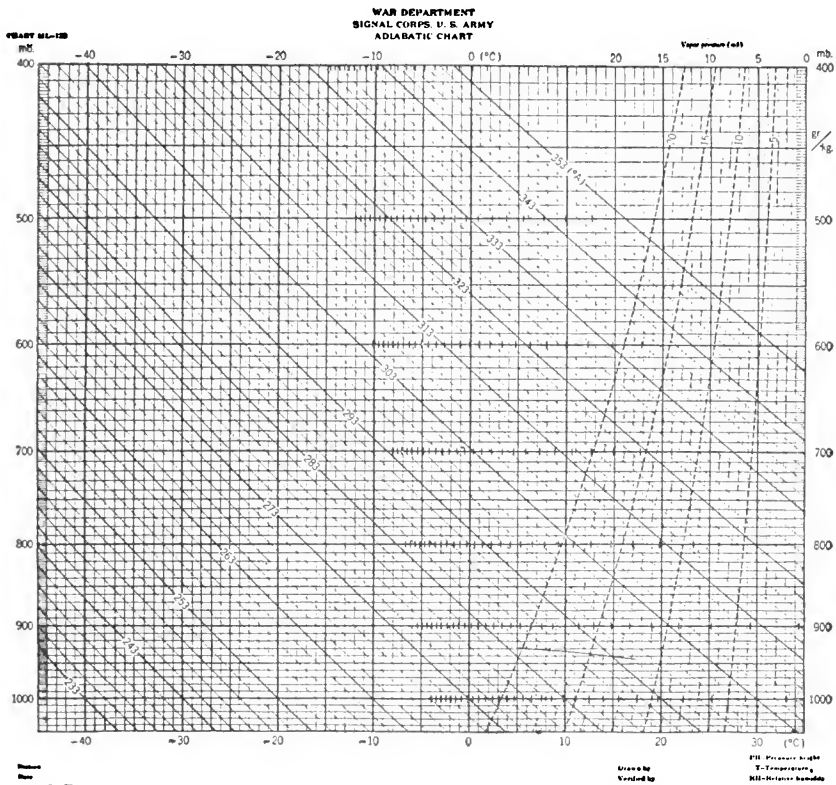


FIGURE 162.—Chart ML-123.

deducing the value for the virtual temperature, as will be explained later.

(2) *Chart ML-124.*—The pseudo-adiabatic diagram ML-124 is shown in figure 163.
Abscissae, representing temperatures in degrees centigrade, are in brown, as are the ordinates, which are the 0.288 power of the pressure values in millibars. The brown lines which slope upward from right to left are lines of constant potential temperature, or "dry adiabats," and are drawn for every 2° Absolute. The broken green curves give the temperature-pressure relations for saturated air and are known as

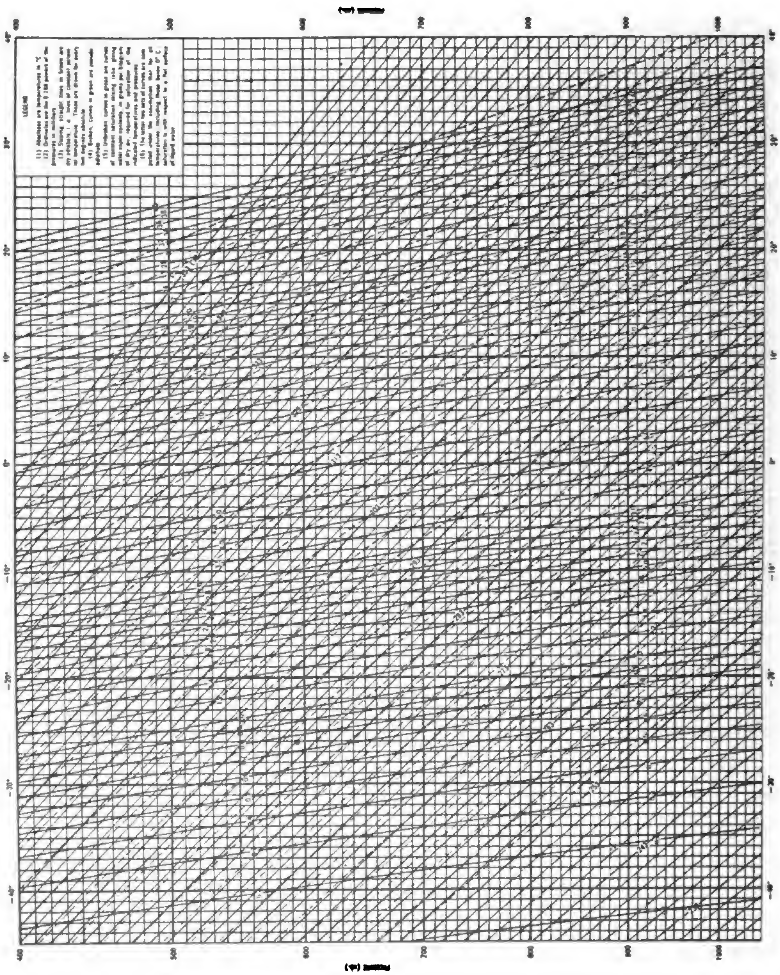


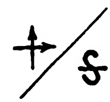
FIGURE 163.—Chart ML-124.

"saturated adiabats." Unbroken green curves are for values of constant saturation mixing ratio, giving water vapor contents in grams per kilogram of dry air required for saturation at the indicated temperatures and pressures. In this connection, it will be well to remember that because the numerical value of the difference between specific humidity and mixing ratio is very small, these values can be used interchangeably without introducing any appreciable error.

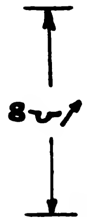
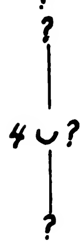
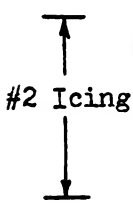
c. *Method of entry.*—(1) The same method of entry of all pertinent data is used for both chart ML-123 and chart ML-124. The coordinates of each significant level are determined by inspection of the RAOB message, and will be plotted as a point circumscribed by a small circle of approximately ⅛-inch diameter. Straight lines are drawn from point to point connecting consecutively each successive significant level. The altitudes above sea level of the significant levels will be indicated by numerals representing hectometers, placed immediately to the left of the circle. The relative humidity which prevails at a given level will be indicated by numerals entered immediately to the right of the circle. The code designator of the station, the date and the time of the sounding followed by a short dash (—) will be placed at the top of the chart.

(2) Clouds and special phenomena as transmitted in the RAOB message will be entered on the chart ML-124. When the base or the top, or the base and the top, of any cloud or special phenomenon is reported, the level or levels will be indicated by a short horizontal line approximately ¼ inch long, and entered at the reported pressure level, to the right of the curve and removed therefrom by approximately 2 inches. If the base or the top, or the base and the top of any cloud or special phenomena are not sent, do not draw the short horizontal line, but enter an interrogation mark (?) at the probable pressure level at which the cloud type or special phenomenon is believed to exist. Halfway between the upper and lower limits established by either the horizontal lines or interrogation marks, enter a numeral denoting the tenths coverage, the cloud symbol, and a small arrow indicating the direction the clouds are moving. If the phenomena are other than clouds, the symbol or word representing the nature of the phenomenon is to be entered. From the cloud symbol or special phenomenon representation, draw two arrows pointing to the short horizontal lines or the interrogation marks. When the cloud direction is not known, a small interrogation mark (?) will be entered in lieu of the direction arrow.

(3) The special phenomena will be entered on the chart as follows:

Code figure	Explanation	Chart entry
0	Rime or frost	Rime or frost.
1	Hard ice	Hard ice.
2	Haze or smoke	∞
3	Dust or blowing snow, or both	
4	Fog	$\equiv$
5	Drizzle	, ,
6	Rain	• •
7	Snow	$\ast\ast$
8	Hail	$\overset{\triangle}{\nabla}$
9	Thunderstorm, or turbulence	Turbulence.

When icing conditions are present, this phenomenon will be entered in a manner similar to other special phenomena, with type of icing designated by a numeral and the word "Icing" written in between the arrows. Examples:

	8/10 stratocumulus clouds, moving from the southwest, with level of both base and top reported.
	Haze, with bottom unknown, but top reported.
	4/10 altocumulus clouds, direction unknown, with both base and top unknown.
	#2 type icing condition, with base and top of stratum reported.

(4) It is not desired to restrict the use of adiabatic charts to any one method, but since its greatest utility lies in the fact that it readily points out changes in thermal structure within a given air mass, and since the probability of the given air mass resting over a certain station on successive days predominates over that for a change of air mass, it is generally found to be advantageous to plot several days' soundings for any one station on the same form. Not only are variations in thermal structure, such as lapse rate changes and the raising or lowering of subsidence inversions, clearly indicated for any one air mass from day to day, but envelopment by a different air mass is frequently

definitely indicated. Where such a method is employed, it has been found that about 4 days' soundings can be plotted on one form before the data for any one day becomes confused with other entries. Under such a system, different colors should be used for the several days, with the color scheme shown in the key at the top of the chart giving the time and date of the sounding followed by a short horizontal line, all in the color selected for that day. If a 4-day series is adopted, the same sequence of colors should be used in each series. All entries for a given day should be in the key color.

d. Errors.—Frequently errors are encountered in the RAOB, due to teletype machine and line trouble, or mistakes in typing the message. These errors, which are usually quite obvious, may be readily corrected by one of the following means:

(1) *To correct an error in pressure value.*—Plot a pressure-altitude curve on a graph the ordinates of which will be pressure values and abscissae will be altitude values. A convenient form will be to do this directly on chart ML-124, using the established pressure ordinates, and labeling the abscissae, from right to left, in hectometers. All points of the sounding should lie on, or very close to a mean straight line drawn through these points. A point obviously off this line should be displaced vertically till it lies on the pressure-altitude line, and the pressure value at this new point used in plotting the adiabatic chart.

(2) *To correct an error in altitude value.*—By use of the auxiliary pressure-altitude curve described in (1) above, the correct altitude for any significant point can be determined for a point that does not coincide with the mean line by displacing this point horizontally till it rests on the mean line, and taking the altitude value of this new point.

(3) *To correct for an error in temperature.*—Check values in the message by the formula $w_s \times f = w$, where w_s=saturation mixing ratio, f=relative humidity, and w=existing mixing ratio, and move the point on the adiabatic curve horizontally till it is at the proper value for w_s, as shown by the sloping solid green line, and accept the temperature value at this new point.

(4) *To correct an error in relative humidity.*—By use of the formula given in (3) above, calculate the correct value of f.

(5) *To correct an error in mixing ratio.*—By use of the formula given in *c*(3) above, calculate the correct value of w.

(6) *To enter corrections.*—When it has been necessary to correct the reported values, the points on both the adiabatic curve and Rossby diagram will be entered as customary, using the corrected values, but

the line connecting this point to the preceding point and the following point will be drawn as a dashed line rather than a solid line.

e. Supplemental uses of adiabatic charts ML–123 and ML–124.—(1) It may be desirable at times to construct a pressure-altitude curve. The grids of both charts ML–123 and ML–124 are suitable for this purpose, using the pressure ordinates as established on the chart, and labeling the abscissae in hectometers. The usual method is to start with the surface point at the right of the chart, and label the progressively higher values moving from right to left.

(2) The specific humidity value at any point on the adiabatic curve can be readily obtained from use of chart ML–123. Plot the point on the right hand area of the chart, using the established pressure ordinate, and vapor pressure in millibars as the abscissa. This latter value can be readily computed by use of formula $f=\frac{e}{e_{max}}$, where f is the relative humidity, e the existing vapor pressure and e_{max}, the saturated vapor pressure. The value of f is known and e_{max} can be found by reference to psychrometric tables. It was previously noted that the abscissae are labeled for vapor pressure in millibars along upper right border. From the position of the point thus spotted the existing specific humidity can be determined, as it will lie on one of the sloping dashed lines on the right of the chart, which are labeled to give specific humidity values in grams of water vapor per kilogram of air. If the plotted point is not exactly upon one of these lines, the value of the specific humidity will be determined by linear interpolation between the two adjacent lines.

(3) The virtual temperature of any point on the adiabatic curve may also be determined by use of chart ML–123. Displace the point vertically (up or down) to the closest horizontal line representing an exact multiple of 100 millibars of pressure. Along each such horizontal line it is noted there are vertical lines of ⅛-inch length, unevenly spaced. The displaced point will usually lie between two such lines, and the difference in temperature between these two vertical lines is *added* to the raw temperature of the point in question on the adiabatic curve to determine its virtual temperature.

(4) The mixing ratio of any point on the adiabatic curve drawn on chart ML–124 can be readily determined by multiplying the value of the constant saturation mixing ratio by the relative humidity value.

89. Rossby diagram.—*a. Purpose.*—The Rossby diagram is used to depict the degree of stability of an air mass by inspection, and to afford a means of comparison of air masses at various stations and at

successive stages in their life history. Conservative properties are used as coordinates of the points plotted so that the curve represents a good means of graphic representation and comparison. The data for the curve are obtained by aerological soundings and derived by use of the adiabatic curve on ML-123 or ML-124. The adiabatic curve and Rossby diagram supplement each other, and final results of the analysis will be most accurate when they are used in conjunction.

b. Description.—Chart ML-106 is used for preparing the air mass characteristic curves. It has ordinates representing the potential temperature of the dry air and abscissae representing mixing ratio in grams of water vapor per kilogram of dry air. The brown lines which slope upward from right to left represent values of constant equivalent-potential temperatures. Isobars and isotherms for the condensation level have been entered on the chart as full green lines. Chart ML-106 is shown in figure 164.

c. Method of entry.—(1) As the difference between the potential temperature of the dry air and the potential temperature of the air at a given level is numerically small, it is customary to plot the latter value as the ordinate. This value is readily determined by inspection of the vertical temperature-pressure curve drawn on either ML-123 or ML-124. It is recognized, however, that the potential temperature of the dry air can be readily determined by use of a formula or appropriate tables. The abscissa of each point on the Rossby chart is the mixing ratio existing at each level which is taken directly from the RAOB message. Using the potential temperature and the mixing ratio as coordinates, each level is plotted as a point circumscribed by a circle of ⅛-inch diameter. Successive levels are connected by straight lines drawn from point to point. The altitude in hectometers, of each significant level, will be indicated by a numeral placed adjacent to the circle in a position where its legibility will not be affected by the connecting line. The code designator of the station at which the sounding was made, the time and date of the sounding, followed by a short horizontal line, will be placed at the top of the chart.

(2) Since this curve is used jointly with that plotted on either ML-123 or ML-124, no notes regarding clouds or miscellaneous phenomena need to be entered on ML-106. Those stations electing to plot a series of adiabatic curves for any one station on the same form, as suggested in the paragraphs on adiabatic charts, will find it advantageous to adopt the same practice for the characteristic curve. The same color code as used on the adiabatic curves should be em-

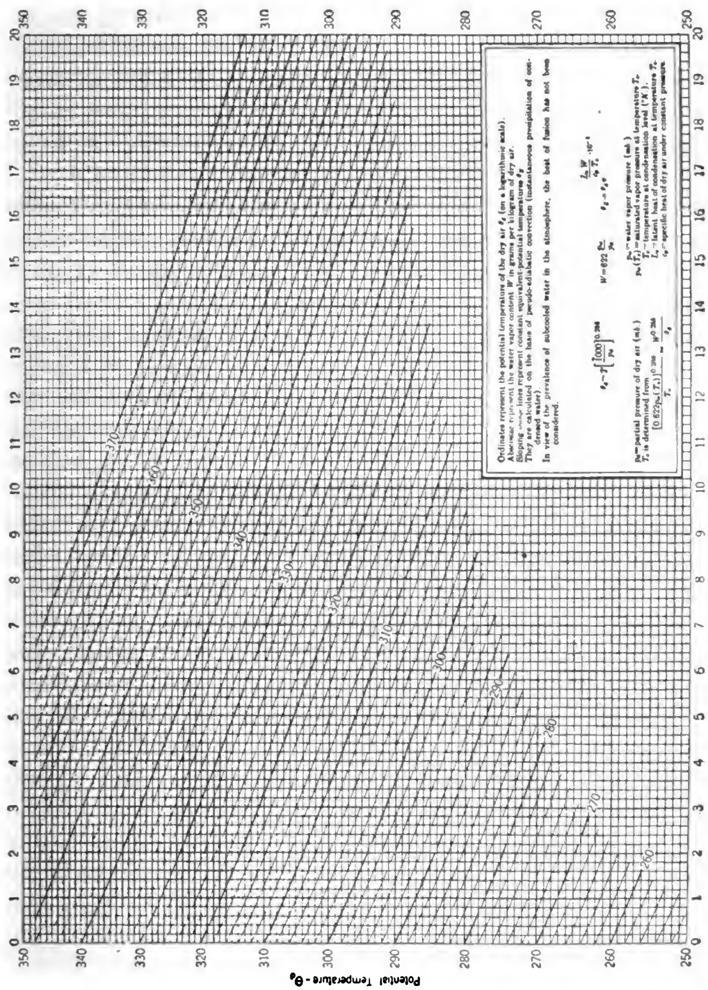


FIGURE 164.—Chart ML-106.

ployed for the Rossby curves, and the color key employed in entering the time, date, and short horizontal line at the head of the chart.

90. Emagram.—*a. Purpose.*—A graphic representation of the energy available for convection in the atmosphere is of material assistance in forecasting certain weather conditions. A most satisfactory portrayal of this latent energy in the atmosphere is by means of the emagram, which has its greatest practical value in forecasting the occurrence of air mass thunderstorms. Thunderstorms of this type owe their production to surface convective currents and the release of energy during condensation after the convective condensation level has been reached by convectively unstable layers of air.

b. Description.—Chart ML-124 is best adapted for use as the emagram, as it provides moist adiabats, represented as broken green curves. A complete description of ML-124 has been given in the paragraph on the adiabatic chart.

c. Method of entry.—An adiabatic curve is plotted and drawn in conformity with the instructions outlined in the paragraph pertaining to that type of curve. It will not be necessary to include notes on clouds or miscellaneous phenomena. Omit, also, entering the relative humidity for each level plotted, and enter instead, to the right of each circle, the value of the mixing ratio for that level. When this adiabatic curve is drawn, the forecaster will determine the convective condensation level (CCL), and indicate the negative areas which will be shaded solidly in blue, and the positive areas which will be shaded solidly in red. Positive areas will represent the amount of energy available for release at and above the level where instability develops, and occur only when the air mass curve lies to the left of the saturated adiabat through the convective condensation level. A negative area will occur when the air mass curve is to the right of the saturated adiabat through the convective condensation level, and represents a stable condition which tends to retard convection. When the positive area is large, the probability of a thunderstorm may be forecast, whereas if it is small, or the area is negative, there will be little or no energy released through lifting and the storm will be very mild if it occurs at all. Generally, a negative area of 2° width and 10 millibars in depth is sufficient to preclude the possibility of a thunderstorm.

91. Snow cover map.—*a. Purpose.*—The map showing that portion of the country which has snow cover, and also the varying depths of this snow cover, is prepared from data included in the 0030 GMT and 1230 GMT weather code reports during the months of November to April, inclusive. The presence of snow on the earth's surface has

a marked effect on the lower levels of the atmosphere overlying this snow surface. In particular, the cooling and drying effect of the snow tends to stabilize these lower levels so that adjacent stations within the same air mass exhibit widely differing weather when one has a snow covered surface and the other has not.

b. Description.—The snow cover map may be drawn on chart ML-108A, described in the paragraphs referring to the wind-aloft chart. Successive sections may be used, so that a series of maps covering a 9-day period will appear on one chart. An outline map of the United States, such as type ML-86-B, is also suitable for use as a snow cover map.

c. Method of entry.—(1) The depth of snow coverage for each reporting station will be indicated by black ink numerals superimposed on the station circle, large enough in size to be clearly legible. When there is no station circle on the map to indicate the position of the reporting station, the entry will be made at the geographical position of the station. The entry on the map will be the highest value of the depth range denoted by the code figure sent.

(2) Boundaries of areas covered by a given depth range will be drawn as smooth curves, and these areas shaded in contrasting colors according to the code shown below.

Code figure	Depth range (inches)	Map entry	Color
0	Trace to 0.9	0. 9	Light green.
1	1.0 to 2.9	2. 9	Light yellow.
2	3.0 to 4.9	4. 9	Light red.
3	5.0 to 6.9	6. 9	Deep red.
4	7.0 to 8.9	8. 9	Do.
5	9.0 to 14.9	14. 9	Do.
6	15.0 to 20.9	20. 9	Do.
7	21.0 to 26.9	26. 9	Do.
8	27.0 to 32.9	32. 9	Do.
9	33 or more	33+	Do.

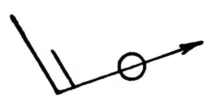
92. Upper air charts.—*a. Purpose.*—Upper air charts are drawn for the 5,000-, 10,000-, 15,000-, and 20,000-foot horizontal planes above sea level to show the pressure fields, change of temperature values, and wind speeds and directions at representative stations in the United States. The data necessary in drawing this map are collected from the RAOB message and wind-aloft message. In addition to being of assistance to the pilot in selecting a flying level, the map will

contain information of synoptic importance to the forecaster. The changes in the pressure fields with increased altitude, the tilt of the axis of highs and lows, the flow pattern of the air at these different planes, and the 24-hourly temperature change lines are of material assistance to the forecaster in preparing his forecast.

b. Description.—The upper-air charts will be prepared and drawn on a base map, such as ML-86-B. This is an outline map of the United States, with reporting stations indicated by small circles and identified by their numeral code station designator placed below the circle. Each level drawn will be properly labeled as to elevation, date, and time.

c. Method of entry.—(1) Pressure values in whole millibars will be entered to the upper right of the station circle in black ink, and temperature values will be entered in degrees centigrade under the entry for pressure. Immediately to the left of the station circle, enter values for 24-hour changes in temperature. Temperature increases will be entered in red, while temperature decreases will be entered in blue.

(2) The wind direction for each level at each reporting station will be represented by an arrow drawn through the station circle, shown as flying with the wind. The shaft will be ¾ inch long, with equal segments extending on each side of the station circle. The wind speed will be indicated by barbs attached to the end of the shaft, a full barb indicating a speed of 10 miles per hour, and a half-barb representing a speed of 5 miles an hour. Draw these barbs extending from the left side of the shaft, as indicated in the illustration below:



(3) Isobars will be drawn in black ink for each 3-millibar interval, drawing for values divisible by 3. Each isobar will be appropriately labeled. Centers of high and low pressures will be indicated by upper case letters, a blue H or red L being entered to show the regions of high or low pressure, respectively.

(4) Lines representing changes of temperature in the last 24-hour period will be drawn as smooth curves for each 3° interval, drawing for every value divisible by 3. All lines showing temperature increases will be in red, and all showing decreases will be in blue. The line through stations having no temperature change in the last 24-hour period will be in green. All of these isopleths will be appropriately labeled.

(5) When the indices provide sufficient information, fronts on these upper planes will be drawn similar to those on the surface map.

93. Pressure change map.—*a. Purpose.*—The structure of the isallobaric field is portrayed by the pressure change map, drawn from data received in the 6-hourly numeral weather code. Its primary purpose is to aid in predicting the direction and speed of movement of pressure systems. It will also indicate changes taking place within the systems themselves, as deepening and filling. The isallobaric field will also aid in the determination of the velocity of the isallobaric component of the wind.

b. Description.—A base map, such as ML-86-B, will be used upon which to draw the pressure-change map. This map is an outline map of the United States, with reporting stations indicated by a small circle and identified by their numeral code station designator entered directly under the circle.

c. Method of entry.—The 3-hourly pressure change in tenths of millibars will be plotted above the station circle in black ink. Tendencies showing pressure increases will be designated by a plus (+) sign preceding the tendency amount, and decreases will be indicated by a minus (—) sign preceding the numeral entry. The isallobars will be drawn for each %₀ millibar change, and will be carefully smoothed. Isallobars of rising pressure will be drawn in solid blue lines and those of falling pressure in solid red lines. The isallobaric centers will be marked by large numerals, in appropriate colors; the anallobars in blue, and the katallobars in red.

94. Atmospheric cross sections.—*a. Purpose.*—An atmospheric cross section is a diagrammatic representation of the moisture and temperature distribution along a vertical plane between points on the surface. From it, the pilot can tell at a glance the regions in which he will likely encounter hazardous flying conditions, and consequently it is a material aid in planning a flight. The distribution of moisture and temperature, the regions of cloudiness and precipitation, wind direction and speeds, and the position and slope of fronts which are represented on the cross section also assist the forecaster in making an accurate analysis and forecast.

b. Description.—Until such time as a standard form is approved and issued, each station will improvise their own forms for this purpose. In every case, the surface profile of the section should be shown along the base of the form and lightly shaded or hatched in green. The relative position of important stations along the section will be plainly marked. Vertical lines should be drawn from all sta-

tions at which atmospheric soundings or pilot balloon observations are made. The ordinate scale will show pressure values in millibars, arranged on a logarithmic scale, with corresponding altitude values in feet and meters entered adjacent to the pressure values. Horizontal distances will be the abscissae of the diagram.

c. *Method of entry.*—(1) Values of potential temperature, temperature, specific humidity and relative humidity will be entered for each significant point of each sounding, falling within range of the form. All such entries will be made in black ink. A small circle, of about ⅛-inch diameter, will be made at the appropriate pressure of each significant level. The potential temperature in degrees Absolute will be entered slightly above and to the left of the circle. The temperature, in degrees centigrade, will be entered slightly below and to the left of the circle. The specific humidity will be entered slightly below and to the right of the circle, and the relative humidity will be entered slightly above and to the right of the circle.

(2) Cloud forms with amount and direction included, hydrometeors, and any other phenomenon will be entered along the vertical scale for each reporting station by the same methods as are prescribed for entry on adiabatic charts. These methods are outlined in paragraph 88.

(3) Wind direction and speed will be entered along station verticals for all stations along the section making wind-aloft reports. The wind direction will be indicated by an arrow, in black ink, drawn at the proper level, and oriented to agree with the direction of the section. To facilitate the correct plotting of the wind directions, an eight-point direction scale will be drawn in both the left-hand and right-hand margins, so that the scale directions will agree with the direction of the section. For example, on a section between two stations which has a direction from NW. to SE., a NE. wind will be indicated by an arrow directed downward, a NW. wind by an arrow directed from left to right, a SE. wind by an arrow directed from right to left, and so on. Thus, by inspection, the perpendicular component into a front may be readily determined. The wind speed will be shown by barbs in the same manner as specified in paragraph 92*c* for winds on upper air charts.

(4) The line along which the potential temperature is that chosen for the isentropic surface for the day, will be drawn as a smooth full curve, using a red pencil. The height of this surface, for any station along the section not making an upper air sounding, can be readily determined from the contour lines of the isentropic map.

(5) All lines of equal potential temperature will be drawn as smooth dotted or broken curves, using a soft black lead pencil, and will be

drawn for every 3° interval from the potential temperature of the isentropic surface chosen for that day. All lines of equal potential temperature will be appropriately labeled. Lines of equal specific humidity will be drawn as smooth full curves, using a soft black lead pencil. A line will be drawn for each whole gram of water vapor per kilogram of air, and appropriately labeled. The 0° C. isotherm will be drawn in as a smooth full green line.

(6) Frontal surfaces of discontinuity and air mass symbols will be entered by use of same conventions as prescribed for surface weather maps. cP air masses will be shaded solidly in dark blue, mP air masses in light blue, and mT air masses in light red. Care must be exercised to do this evenly and neatly in order that the legibility of all entries will not be affected.

95. Isentropic chart.—*a. Purpose.*—Upper-air charts that are drawn for a surface of constant potential temperature provide a means of following the flow patterns in the atmosphere more accurately than one can along constant altitude levels. As a surface of constant potential temperature is also a surface of constant entropy, such charts are called isentropic charts. Mixing ratio or specific humidity values are conservative properties of the atmosphere so the streams of air flow along an isentropic surface can be followed on succeeding maps by using this function of the humidity of the atmosphere as an identifying element. The contour of the isentropic surface and the air-streams along this surface greatly influence the future weather conditions and a knowledge of these factors as can be deduced from an isentropic map assist in making an accurate forecast.

b. Description.—The isentropic chart will be prepared on base map ML-86-B, or similar type, that gives an outline of the United States. The RAOB message contains data for three different isentropic surfaces, but ordinarily one surface only is selected for analysis. The forecaster will choose the level of the chart, and will select the one high enough to be above the layer influenced by surface friction and other nonadiabatic processes, but low enough to show, by specific humidity values, the flow of moist and dry tongues along the isentropic surface.

c. Method of entry.—(1) The isentropic map will be appropriately labeled with respect to the potential temperature surface it represents, and the time of the soundings.

(2) The basic data used in constructing the isentropic chart are: Values of specific humidity, relative humidity, atmospheric pressure at the isentropic level; atmospheric pressure at the condensation level for points on the isentropic surface; weight of the column of air con-

tained between the isentropic surface selected for analysis, and the next higher one for which data is sent which differs by 6° in potential temperature value; the change in weight in this column in the past 24 hours; the height in meters of the isentropic surface; values of the stream function, clouds, hydrometeors or other phenomena occurring at the reporting station; wind speed and direction on the isentropic surface; the direction and magnitude of the shear-stability ratio vector; and the pressures on the isentropic surface perpendicular to the SSRV vector whose *actual* temperatures are 5° C. greater and 5° C. less than the station's actual temperature at the isentropic level.

(3) All entries will be made in black ink.

(4) Relative humidity values will be entered to the right and above the station circle. It will be determined by linear interpolation from the adiabatic curve, and entered as a numeral representing whole percent.

(5) Specific humidity values will be entered immediately to the right of the relative humidity and will be separated from it by a diagonal mark (/). Values will be entered to tenths of a gram of water vapor per kilogram of air, and will be determined from the adiabatic curve, by multiplying the saturated specific humidity value by the relative humidity at the isentropic level.

(6) The atmospheric pressure, taken directly from the RAOB, will be entered in whole millibars to the right of the station circle just below the relative and specific humidity entries.

(7) The condensation pressure level will follow immediately to the right of the atmospheric pressure and will be separated therefrom by a diagonal (/) mark. This entry will be in whole millibars.

(8) The difference in atmospheric pressure between the isentropic surface to be analyzed and the one above, which has a potential temperature 6° Abs. higher, is an indication of the weight of a column of air between these two surfaces, and in this value will be entered, in whole millibars immediately below the atmospheric pressure entry. This entry is obtained from the RAOB by subtracting the atmospheric pressure of the higher isentropic surface from that of the lower.

(9) The change in the difference in atmospheric pressure in the past 24 hours is entered immediately to the right of the entry for the difference in atmospheric pressure, in whole millibars, and is separated from the preceding entry by a diagonal (/) mark. This value is obtained by comparing the present value with the one of 24 hours previous, and is indicated as a plus (+) or minus (—) change. This entry is an indication as to whether the air column is becoming more

or less thermodynamically stable, a decreasing value denoting a more stable condition, and vice versa.

(10) The height of the isentropic surface in meters will be entered to the right of the station circle below all other entries. It will be obtained by linear interpolation on the adiabatic curve, or from a pressure-altitude table.

(11) Stream function values, in millions of ergs per gram will be entered to the left of, and slightly below, the station circle.

(12) Cloud entries will be made to the left and slightly above the station circle. International symbols will be used. The direction of motion will be shown by a small arrow appended to the right side of the symbol. When the direction is unknown, a query mark (?) will be entered. The amount of sky cover, in tenths, will be indicated by a number to the left of the symbol. When two or more cloud forms are reported, the entries will be made one above the other. If the cloud is below the isentropic surface, the lower case "b" will be entered immediately below the cloud symbol. If the cloud is above the isentropic surface, the lower case "a" will be entered immediately below the cloud symbol, and if the cloud penetrates the isentropic sheet, the lower case "p" is entered below the symbol.

(13) Precipitation or special phenomena present at the station will be entered above the station circle, using international symbols.

(14) Wind velocity, at the isentropic surface, will be entered for all stations reporting atmospheric soundings and for all those for which the altitude of the surface may be determined by isentropic contour lines and for which wind-aloft data are available. Direction and speed will be indicated as prescribed in drawing the arrows for upper air charts.

d. Drawing the isentropic chart.—(1) The contour of the isentropic sheet will be shown by drawing isobars for all atmospheric pressure values which are multiples of 50, with black ink, and appropriately labeled.

(2) Stream lines will be drawn, in smooth yellow curves, through every value of the stream function which is a multiple of 5. These lines will approximately represent instantaneous wind flow on the isentropic surface. Arrow heads will be put on each stream line at several points to indicate the direction of flow, and in all cases lines through lower values will be to the left of the direction of flow.

(3) Lines will be drawn, in red, through points of equal condensation pressure, which are multiples of 50, and appropriately labeled. They will indicate the distribution of moisture in the atmosphere at the isentropic level, with higher values of condensation pressure represent-

ing greater water vapor content. Wherever a saturation area exists, that region will be hatched with closely arranged parallel red lines. These areas will be located by the fact that condensation pressure lines would be equal to, or seemingly greater than, the atmospheric pressure.

(4) All areas showing representative increases in moisture content will be shaded lightly in red, and those showing representative decreases in moisture content will be shaded lightly in blue.

(5) The axis flow or wake streams of tongues of air showing increases and decreases in moisture will be represented by heavy solid arrows in their proper color. Past trajectories of these tongues, when it is necessary to show them, will be indicated by heavy broken lines in the appropriate color.

SECTION VIII

TELETYPE OPERATION AND PROCEDURE

96. General.—The Civil Aeronautics Administration of the Department of Commerce administers an extensive and elaborate teletype communication system. The development and extension of this sytem has been the result of steadily increasing demands for adequate communications by the rapidly expanding aviation field. This communication system now embraces in reality three systems. Each of these is devoted to a restricted form of traffic, differing from the other two. Together they have become the most important means available for the collection and dissemination of all types of information dealing with the problems of air operations. Traffic volume has become so great that automatic transmission is now used almost exclusively. The speed normally employed is 60 words per minute. Time is at such a premium, that with scheduled traffic an initiating station is permitted a maximum of but 5 seconds within which to begin transmission. All in all, the rigidly controlled, automatically transmitted traffic on present day teletype systems requires an operator who is thoroughly schooled both in operating procedure and in the handling of equipment.

97. Equipment.—There are four principal items of equipment involved in teletype communication. These units accomplish the

preparation, transmission, and reception of the material. They are as follows: the keyboard transmitting unit, the printer or typing unit, the transmitter distributor unit, and the tape perforator. Two or more of these units may be incorporated into a single composite unit. For example, the model 15 page printer (fig. 165) combines the

FIGURE 165.—Model 15 page printer.

transmitting and typing units. The perforator distributor set (fig. 166) combines the second pair of items. The model 15 page printer and the perforator distributor set together comprise the equipment needed for automatic transmission and reception. The model 19 equipment (fig. 167) consolidates all four items into one article.

Communication with the teletype equipment is accomplished over metallic electric circuits, through the medium of electric impulses. These impulses may be either "marking" impulses or "spacing" impulses. A "marking" impulse results when electric energy is

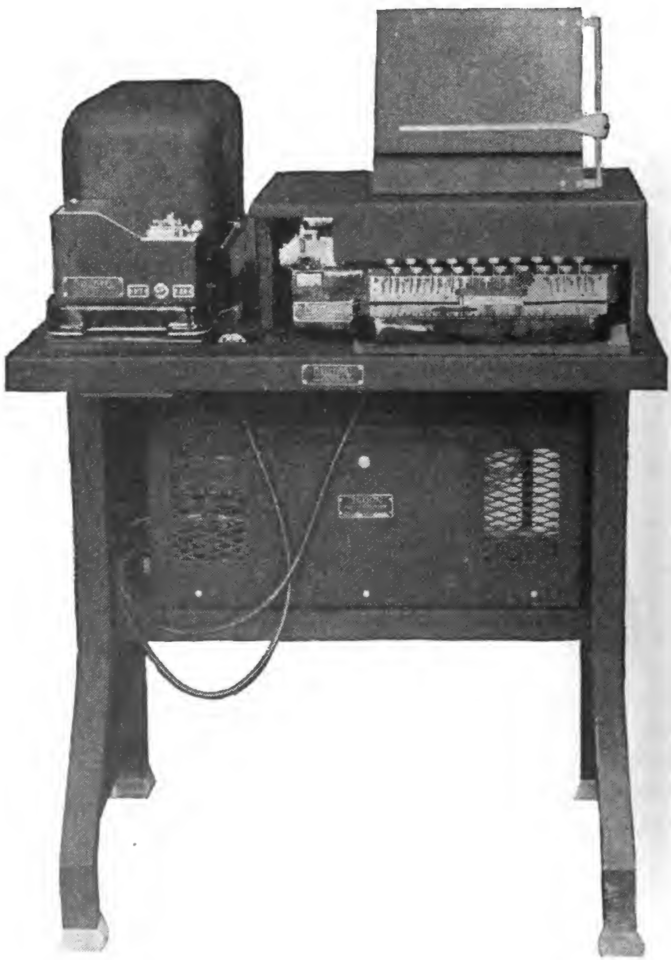


FIGURE 166.—Perforator-distributor set.

applied to the circuit, and a "spacing" impulse results when no electric energy is applied. The code used in teletype signaling is known as the "Five Unit Permutation Code" or the "Five Impulse Start-Stop Code."

Thirty-one different combinations (plus a "blank" combination) of the five impulses are possible with this code. However, the number

of symbols which may be printed is actually almost double the number of impulse combinations. This is made possible by an arrangement similar to that employed by the ordinary typewriter, whereby two characters may be printed by each typebar by simply

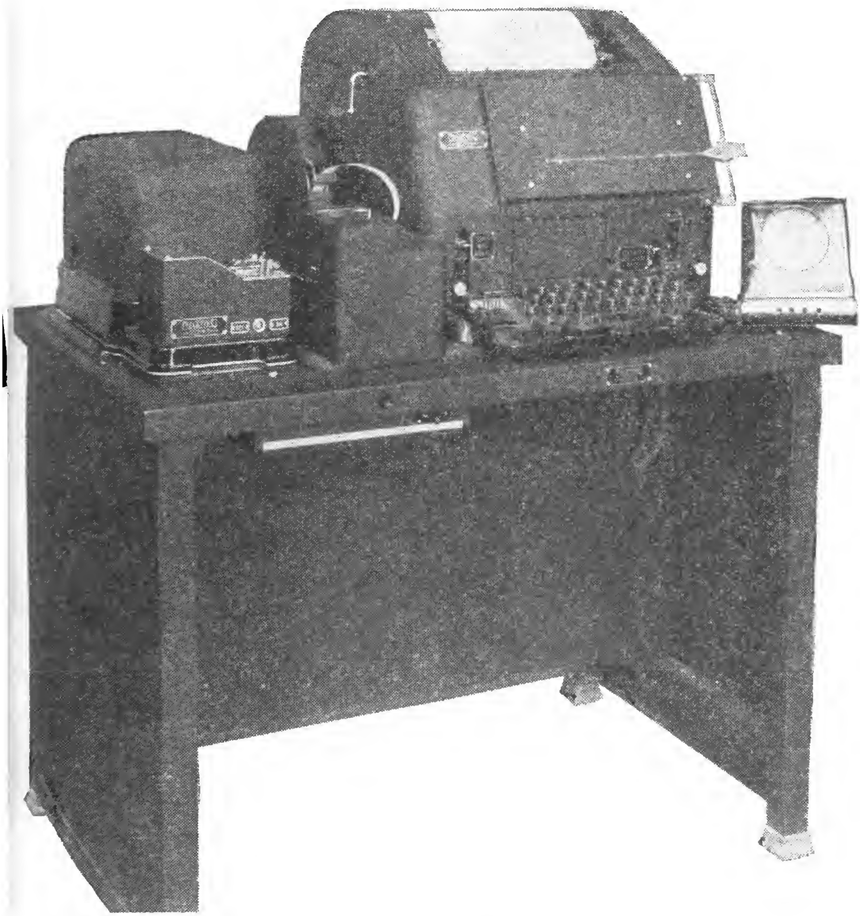


FIGURE 167.—Model 19 composite set.

shifting the carriage of the machine. Of all the various possible combinations of impulses in the teletype code, six must be employed for the transmittal of the so-called "functions." These "functions" are carriage return, line feed, bell signal, figures shift, letters shift, space.

a. Model 15 page printer. (1) *Function.*—This unit serves the dual purpose of providing for manual transmission to receiving units

on the circuit, and for the reception of transmission, either manual or automatic, originating at other points.

(2) *Description and operation.*—(*a*) *Motor control.*—The motor

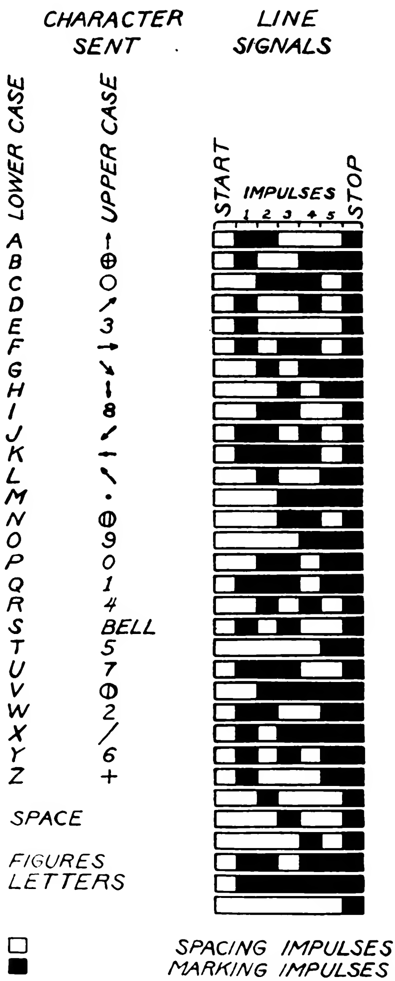


FIGURE 168.—Graphic representation of teletype code.

control switch for the model 15 page printer is located just above and to the right of the keyboard (fig. 165).

(*b*) *Send-receive-break mechanism.* The control lever for the send-receive-break mechanism is located just above and to the left of the keyboard. The upper (send) position of this lever permits transmission by local keyboard operation. The middle (receive) position

allows reception of outside transmission, including that originating within the local transmitter distributor unit. If the equipment is idle with the lever in the "send" position, the first receipt of outside transmission will cause the lever to move automatically to the "receive" position. The lower (break) position provides the means of interrupting transmission already in progress on the circuit. It is thus possible to obtain control of the circuit, even when it is in use. Holding the lever in this position prohibits any transmission being accomplished by causing the circuit to run "open." This operation is resorted to only in case of emergency, hence will be required infrequently.

(c) *Keyboard.*—The keyboard of the model 15 page printer (also that employed by related equipment) is very similar to that of the

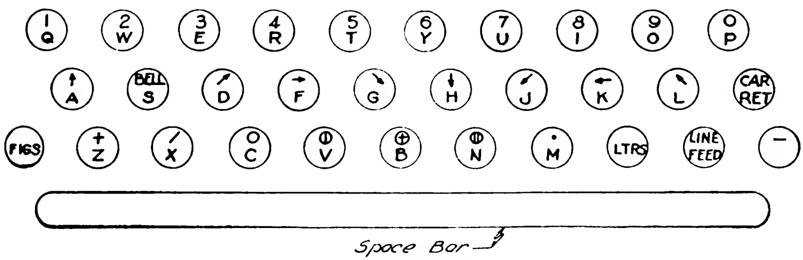


FIGURE 169.—Teletype keyboard.

"all-capital" typewriters used by telegraph and radio operators. Many of the features of operation are similar. The individual typebars, selected by operation of the keyboard, are mechanically thrown against the platen, as in the case of the typewriter. The energy for this operation is furnished electrically, however, rather than by the force which depresses the key. Proper timing thus becomes an important factor, considerably more important than in the operation of the typewriter keyboard. The functions of shifting the carriage into upper or lower case, moving the typebar carriage to the right or left, and line feeding are also performed electrically. Motion of the carriage to the right is provided automatically as each character is printed or as the space bar is depressed. Before the carriage reaches the end of its travel, it operates the margin bell as a warning to the operator that the end of the line is near. Depression of the "carriage return" key returns the carriage assembly to the left margin. *This operation can be performed only when the typebar carriage is in the lower or "letters" position.*

The carriage is placed in position for printing letters or figures by

depressing the "letters" or "figures" key. For normal operation, the paper is advanced to receive a new line by depressing the "line feed" key once for each line advance required. Arrangement for "double spacing," wherein the unit advance is two lines, may be made by advancing the single-double line feed lever to the forward position. This lever is located on the left of the platen roller. Advance by larger increments may be had through use of the handle which is in line with the platen roller on the left.

There is an additional keyboard peculiarity which should be mentioned. When two successive "blank" key operations are made, the "send-receive" lever will return to the "receive" position, and the keyboard will lock. This is purely a protective measure, and necessitates only that the "send-receive" key be returned to "send" in order to proceed. Reception is not affected.

(*d*) *Paper roll.*—The model 15 and other page printers are equipped with paper rolls 8½ inches in width and approximately 1⅝ inches in radius. The core of each roll is a cardboard tube 1¼ inches in diameter. To place the paper in the machine, the roll is first mounted on the detachable wooden spindle. The paper roll is placed on the wooden spindle so that it feeds up from the bottom after being installed, with the encircling retainer spring on the left. The retainer spring may be placed in any desired position in order that different widths of paper may be accommodated. The mounted roll is now placed so that the axle of the wooden spindle rests in the slots provided in the frame immediately behind the carriage assembly. The spindle is held in position by sliding plates. Horizontal displacement is prevented by tension of a band spring fixed to the frame (fig. 170). The paper must feed upward and forward from the bottom. The forward edge of the paper is led over the paper straightener rod (fig. 171) and fed under the platen at the rear. By rotating the platen with the handle, the paper feeds upward under the paper fingers and over the face of the platen. To facilitate straightening the paper, the pressure roller may be released by moving the pressure roller release lever toward the rear. This lever is located at the right end of the platen roller.

(*e*) *Ribbon.*—With each operation, except the "functions," the ribbon is advanced one space. This motion is obtained through a train of gears and shafts causing *one* of the ribbon spools to revolve. The other spool rotates freely, allowing the ribbon to be wound slowly from one spool to the other. When the ribbon is wound on the right-hand spool, and is almost unwound from the left-hand spool, an eyelet which is fastened to the ribbon engages and moves the left-hand ribbon reverse arm.

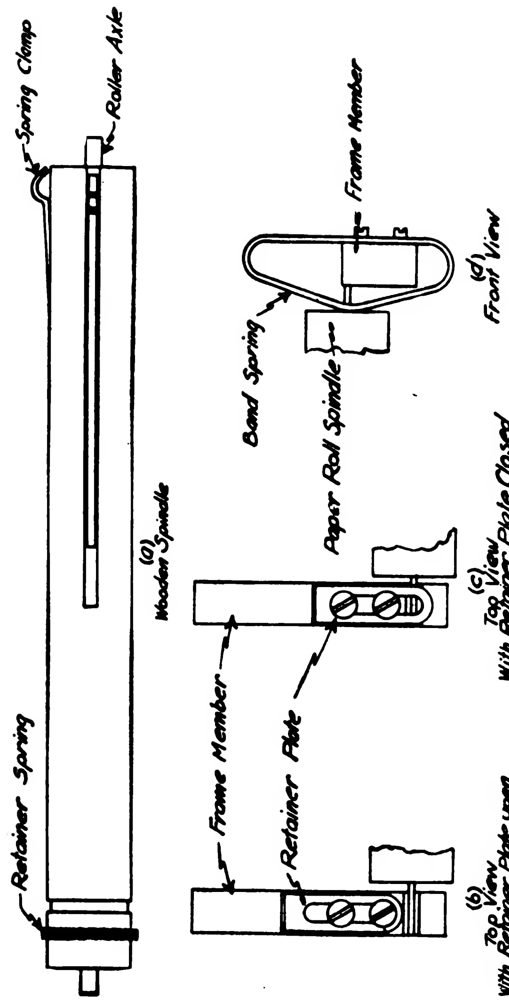


FIGURE 170.—Wooden spindle for paper roll.

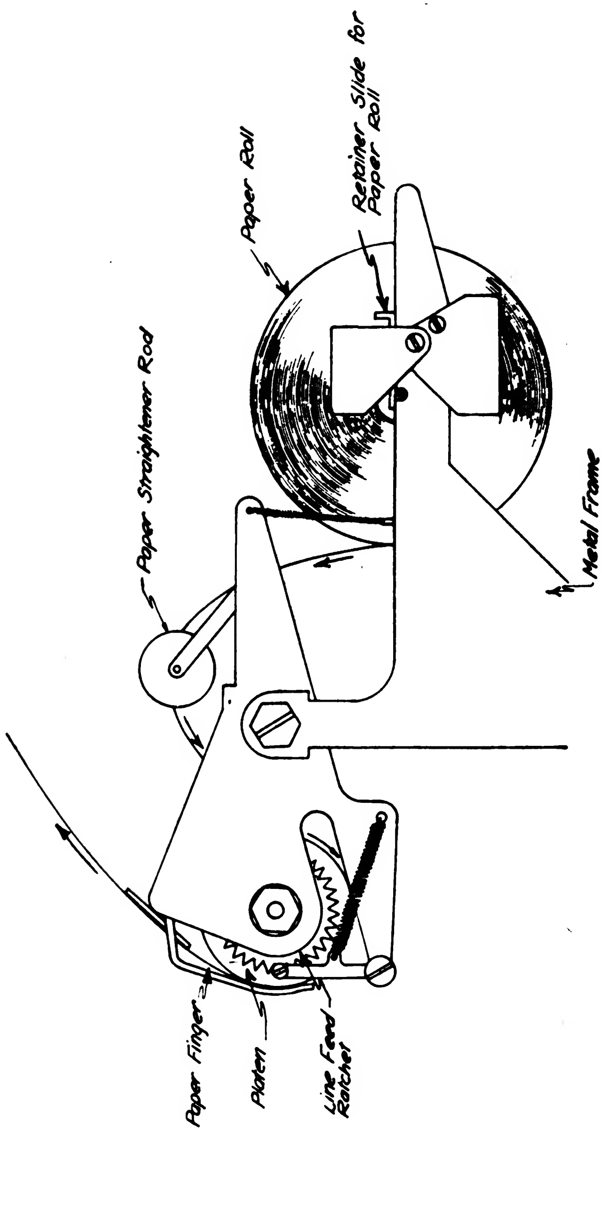


FIGURE 171.—Paper feed assembly.

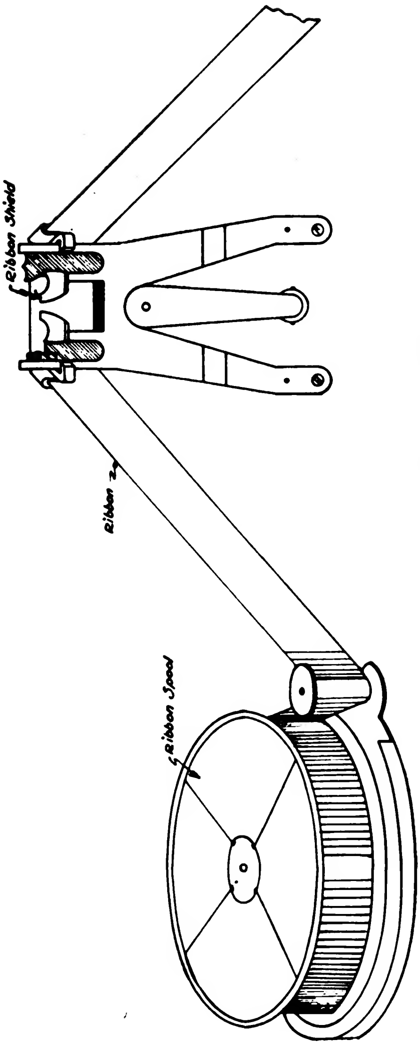


FIGURE 172.—Ribbon spool and ribbon shield unit.

This disengages the right-hand ribbon feed gears and engages the left-hand gears. The ribbon will then be wound on the left-hand spool. A similar operation is performed when the right-hand spool is nearly unwound.

In order not to obscure the material being typed, the ribbon is moved below the printing line after each character has been printed. A ribbon lockout bar is provided for the purpose of locking the ribbon below the printing line when stencils are being made. This bar is located in the center rear of the typebar carriage on the right. It should be moved inward manually to hold the ribbon below the printing line.

b. Tape perforator.—(1) *Function.*—The tape perforator unit is used to prepare perforated tape for automatic transmission to printer units on the circuit. Its operation is local in character and has no immediate connection with the printer circuit.

(2) *Description* (fig. 174).—With this equipment, combinations of

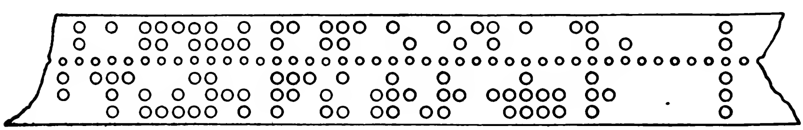


FIGURE 173.—Section of perforated teletype tape.

holes, corresponding to key levers depressed, are perforated in a paper tape.

This perforated tape, with the code combinations thus recorded, may then be fed automatically through a transmitter distributor unit and operate one or more printer units at distant points.

The perforating mechanism consists essentially of a set of electrically controlled punches.

The selection of a given combination of punches is the function of the keyboard of the unit.

After being perforated, the tape consists of a series of punch combinations corresponding exactly to the message "typed" on the keyboard. In appearance, this keyboard is a duplicate of that employed on the printer units. In place of the warning bell found on the printers, a red lamp appears under the keyboard. This is lighted after 65 characters have been perforated. This number is a few less than the allowable number in a printed line, and the light thus serves as a warning that a new line should be started.

For making corrections, a "backspace lever" is provided. This

lever furnishes a means of moving the tape backward for reperforation, as described in (3)(*b*) below.

(3) *Operation.*—(*a*) *Keyboard.*—The operation of the perforator keyboard is similar to that of the printer keyboard. Every operation and function to be performed by the printers, including every character, as well as every "function," must be punched correctly on the tape. Most of the messages prepared by weather personnel are short, normally requiring not more than one line. Ordinarily, such traffic is transmitted to the circuit as part of a "sequence" collection, in which time is an important factor. It is thus very important to be able to terminate a given transmission quickly. This may be done by the use of the tape stop switch on the transmitter-distributor (fig. 166). An automatic means of stopping transmission is as follows: After the perforation for the final character or function has been

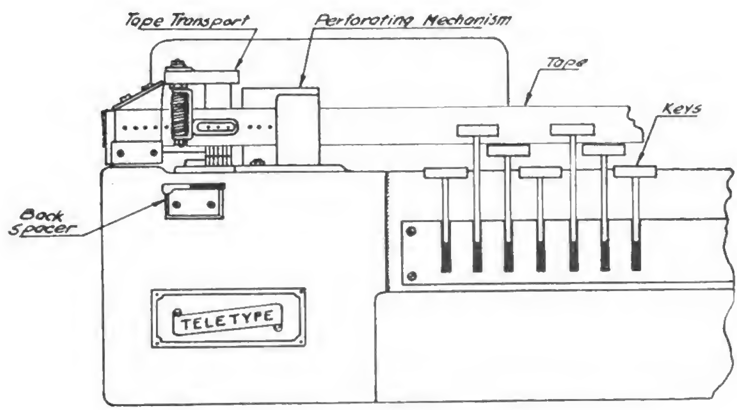


FIGURE 174.—Tape perforator mechanism.

made, strike the "blank" key five times, adding thereby five tape feed perforations; then strike the "letters" key; finally, strike the blank key enough times to permit the tape to be torn along the perforations of the "letters" combination. When the end of the tape is thus separated from the end of the desired transmission by just five spaces, the transmission will be automatically terminated following the last character or "function" (fig. 173). (This device *cannot* be employed on older transmitter distributor equipment.)

(*b*) *Making corrections.*—*In most classes of traffic the use of "corrected tape" is forbidden.* A "correction" is made in a tape by backspacing the tape to the erroneous character and striking the "letters" key. This perforates five holes in this part of the tape and a "letters shift" impulse will be transmitted. In this manner the mistake in

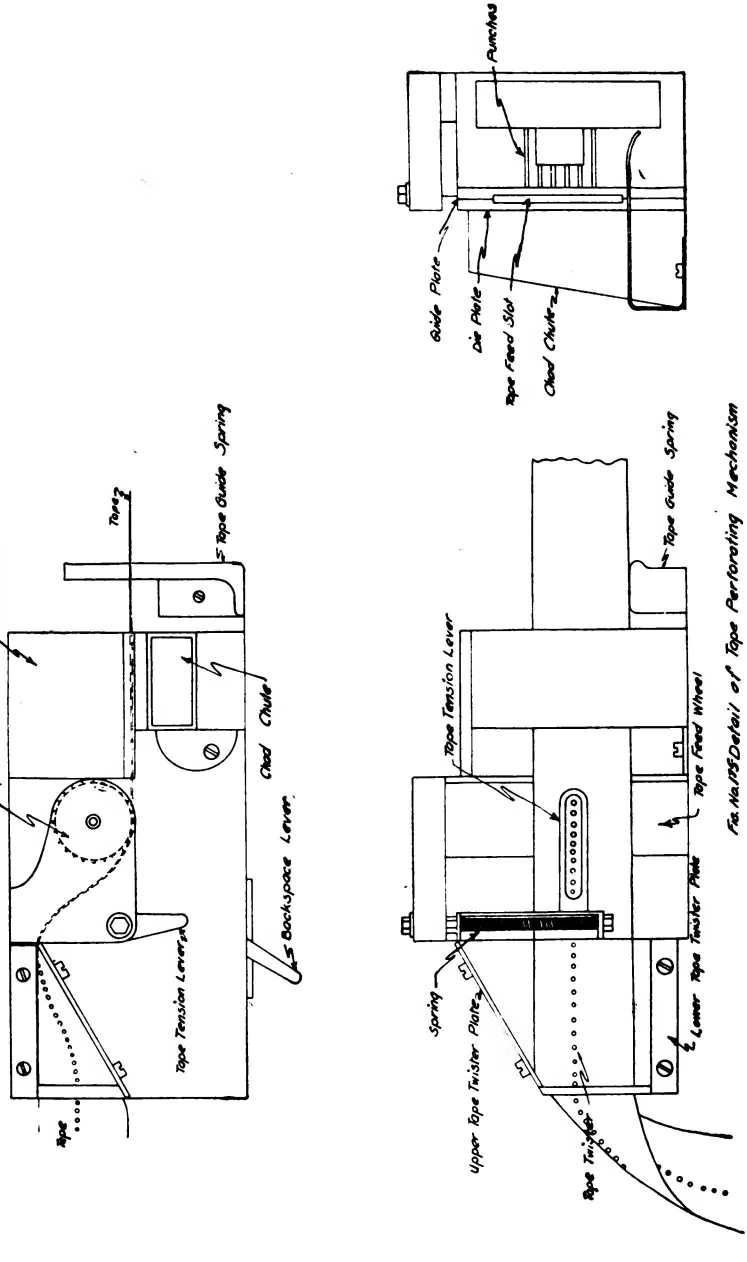


FIGURE 175.—Detail of tape perforator mechanism.

the tape is replaced by an unnecessary (usually) "letters" impulse. This wasting of circuit time is undesirable, and is usually forbidden. If an upper case character is corrected, the "figure" key must be struck before striking the correct key since the "letters" combination would place the receiving equipment in the lower case. If the character to be corrected is not the last for which perforation has been made, all characters following the one in error must also be removed with the letters combination. Tape corrected to this extent is unsatisfactory, and preparation of a new tape is obligatory.

(c) *Starting tape in perforator.*—Tape for use with the perforator is furnished in rolls approximately 11/16 inch wide and 8 inches in diameter. The tape roll should be placed on the feed reel in the manner shown in figure 176.

To start the tape in the perforator, tear it squarely and insert between the die plates of the punch block (fig. 176). Pull the tape tension lever away from the tape feed roll. Push the tape forward until the end of the tape is in position between the tape feed roll and the tape tension lever. Now press the tape tension lever against the tape feed roll, causing the projecting pins in the feed roll to grip the tape. Strike the "blank" key a number of times, and the tape will feed forward.

c. *Transmitter distributor set.*—(1) *Function.*—The purpose of the transmitter distributor is to translate the code combination, perforated in the tape, into electrical impulses and transmit these impulses to the receiving printer.

(2) *Description.*—The transmitter distributor is made up of two principal units: the transmitter and the commutator distributor. The tape transmitter, using the perforated tape, sets up the code combinations to be transmitted. The commutator distributor sends the code combinations over the line as marking and spacing impulses, in proper sequence and at a predetermined speed. The two units are driven together at a constant speed. The tape is fed through the assembly by a tape feed wheel.

The pins of this feed wheel engage the feed holes in the tape, propelling it forward (to the left) as the wheel rotates. The five tape pins are pressed firmly against the tape. As the tape feeds through the mechanism, successive perforated combinations are alined with the tape pins. The tape pins corresponding to the holes punched in the tape at this point are then permitted to pass through. The commutator segment to which a selected pin is connected will send a marking impulse to the line. In this manner, mechanical combinations are translated into electric combinations. These electric

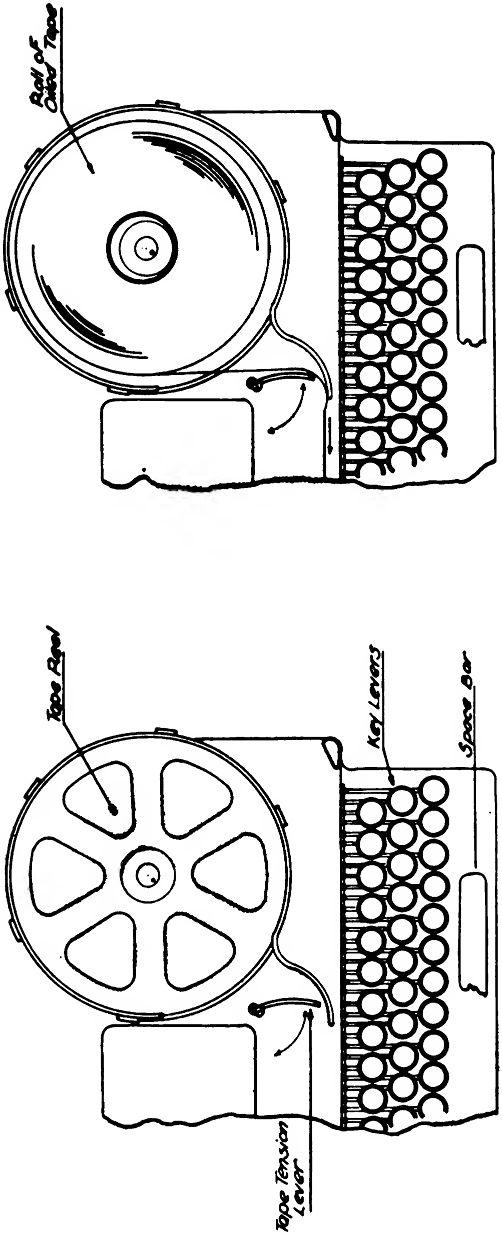


FIGURE 176.—Perforator tape reel assembly.

code combinations are the means by which the receiving units are activated.

(3) *Operation.*—The motor control on-off switch for the transmitter-distributor is the same as that employed by the perforator unit. The starting and stopping of the tape is manually controlled by the start-stop switch on the forward panel of the transmitter-distributor. To transmit by means of a perforated tape, it should be placed on the transmitter assembly so that two conditions are satisfied: First, the feed holes must be clearly in mesh with the tape feed wheel pins; second, the perforated code combination representing the first character to be transmitted must lie directly over the row of tape

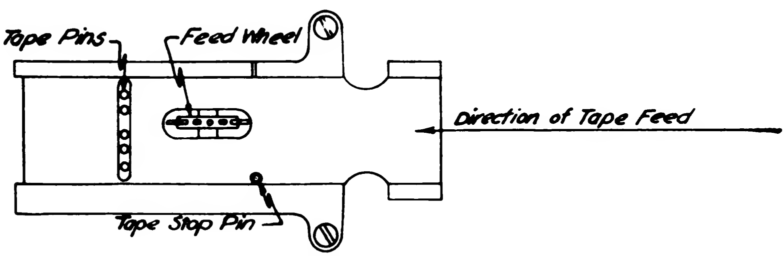


FIGURE 177.—Tape feed and transmitting unit—top view.

pins. When the tape is in place, the hinged clamp is lowered, and the tape is held in position. Then at the proper time, transmission is begun by simply moving the start-stop switch to "start." Termination of the transmission may be accomplished in one of three ways as follows:

(*a*) Manually, by opening the start-stop switch.

(*b*) Automatically, by the passage of the end of the tape over the tape stop pin in the tape track (fig. 177).

(*c*) Automatically, by the lifting of the automatic stop lever which projects forward between the perforator and the transmitter-distributor. Tape feeding into the transmitter is led under this lever. When the tape is pulled taut, the lever is raised, and the transmitter is stopped. This method is employed only when more or less continuous transmission is being accomplished, and perforation is continuing while a portion of the tape is being fed through the transmitter-distributor.

d. Model 19 composite set.—(1) *Function.*—The model 19 composite set (fig. 167) is an arrangement which furnishes at one operating position the three individual items of equipment previously described. The same keyboard is employed for tape perforation as for manual

operation of the printer unit. The transmitter distributor unit is mounted immediately adjacent to the printer and perforator unit, to the left.

(2) *Description and operation.*—The model 19 composite set differs but little in appearance from a simple physical grouping of the several units of which it is composed. It may best be described by noting those differences which do exist. In the discussion which follows, reference should be made to figure 167.

(*a*) *Motor control switches.*—There are two motor control switches on the model 19. They are located approximately 2 inches from the forward edge of the table and about 6 inches from the left end, and on

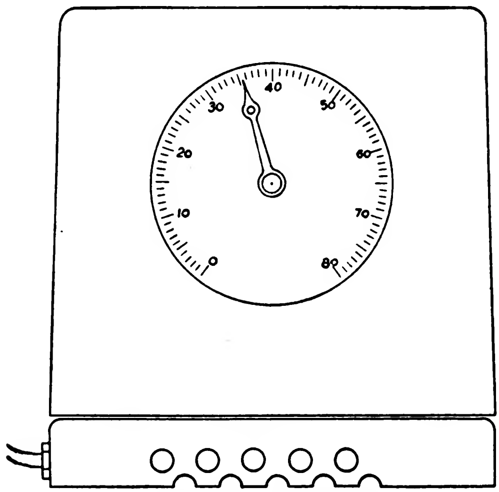


FIGURE 178.—Character counter, model 19 composite set.

the underside of the table top. Of these two switches, the one on the left is the motor control for the transmitter-distributor and is "on" in the forward position; the one on the right is the rectifier control for the typing and printer unit and also is "on" in the forward position. The motor control switch for the printing and typing units of the model 19 is found in a position exactly corresponding to that of the model 15, with the "on" and "off" positions the same.

(*b*) *Character counter.*—In lieu of the warning bell on the model 15 and the red warning light of the perforator, the model 19 is equipped with a character counter and signal lamp. They are mounted on a bracket attached to the right side of the keyboard casting (fig. 178).

The external features of the counter are the dial, indicator, and signal lamp. The indicator moves one space each time a character key is

depressed, and is returned to the starting position when the carriage return key is depressed. The signal lamp serves to indicate the approach of the end of a line. Usually the lamp is lighted after 65 linear spaces have been used, although the mechanism may be set so that the lamp lights after any desired number of characters. The character counter operates only when the keyboard control operating lever ((*c*) below) is in the "tape" position.

(*c*) *Keyboard control operating lever.*—A manually operated three-position keyboard control operating lever is mounted on the right side of the unit immediately to the left of the motor control switch for the typing and printing units. The three positions are as follows: The upper or "keyboard" position is that employed when direct manual transmission is desired; the middle or "keyboard and tape" position is used when simultaneous direct transmission and perforation of tape is desired; the lower or "tape" position is used when perforation of tape only is required. Reception of outside transmission can be in process while the local keyboard is being used to prepare tape only.

(*d*) *Send-receive-break key.*—This key serves the same function and is controlled in the same manner as for the model 15 page printer.

(*e*) *Line switching key.*—The line switching key projects from the forward edge of the table about 13 inches from the left end. This key permits selection of the circuit on which the instrument is to operate at a given time. Three positions are available, of which the center one is usually reserved for local circuit operation. Thus the machine may be arranged to operate on either of two external circuits by placing this key in the left or right position, leaving the center position for local testing and operation.

(*f*) *Q switch.*—Located immediately below the perforator mechanism on the forward edge of the table, about 10½ inches from the left end, is a device known as a "Q" switch. When this switch is depressed, the local printing unit is switched out of the circuit, and incoming impulses are diverted to a "reperforator." A reperforator is a device in which incoming electrical code impulses are converted directly into mechanical perforations on a tape. A permanent record of the transmission may thus be obtained and used to retransmit the traffic so received. The employment of this device is largely restricted to relaying stations.

(*g*) *Perforator unit.*—The perforator unit of the model 19 is almost identical to that of the model 15. The mechanism is exactly the same, and the arrangement differs only in greater compactness.

(*h*) *Transmitter-distributor unit.*—This unit of the model 19 is identical to that employed with the Model 15.

98. Operating procedure.—*a. General.*—The teletype communication facilities of the Civil Aeronautics Administration are operated as three separate systems, known as schedule "A," schedule "B," and schedule "C." Of these three, schedules "A" and "C" are used primarily for transmitting weather information. Schedule "B" is used by the air traffic control system of the Civil Aeronautics Administration for controlling air traffic over the nation's airways.

Schedule "A" is used for the transmission and distribution of hourly weather reports, special weather reports, Notices to Airmen, administrative dispatches, and auxiliary transmissions such as service dispatches, "Q" signal communications, number comparisons, etc.

Following is a list of the various messages which may be sent over schedule "A" teletype circuits in addition to regular sequence collections of hourly weather reports and special weather reports. These messages are listed in the order of their priority.

(1) "SSS" dispatches and communications relative to emergencies involving the safety of life or property which require immediate transmission.

(2) "P" (Priority) dispatches relative to the safety of life or property but which do not involve emergencies and do not require immediate transmission. This includes "flash Notams."

(3) Special (SPL) weather reports (not in sequence collections).

(4) Dispatch Notices to Airmen.

(5) Delayed weather information required for scheduled radio broadcast (preceded by the prefix "P" and the abbreviation "DW" (delayed weather); example:

PDW 1830 RW C, etc.

(6) "D" dispatches of such urgent nature that they cannot be classed with the "W" group. (See below.)

(7) Aircraft advisory messages pertaining to movements of public aircraft.

(8) Delayed weather information not required for scheduled radio broadcast (preceded by the prefix "D" and the abbreviation "DW"; example:

DDW 1830 RW C, etc.

(9) "W" dispatches not included in other classes and not of an urgent nature.

Schedule "C" is used for the transmission and distribution of Pilot Balloon reports (PIBAL), RAOB and APOB reports, 3- and 6-hourly map reports, and forecasts.

b. Hourly sequence weather reports.—(1) *General.*—The main source of weather information used in preparing all types of aircraft flights is the system of hourly sequence weather reports as transmitted over the teletype circuits of the Civil Aeronautics Administration. In this sytem, which is a part of the national communication system of the CAA, weather reporting stations maintained by the U. S. Weather Bureau and the various armed forces of the United States, transmit regularly each hour complete weather reports for each station to many, if not most, of the other network stations. Since many hundreds of stations report each hour, the task of providing for the transmission and distribution of this tremendous mass of data is extremely complex.

In order to obtain workable sized groups of stations for communications purposes, groups of from 20 to 40 stations, arranged in general along one or several closely related airways, are connected together on a long line teletype circuit. Every transmission from one of the stations is thus received at every other station on the circuit. In this manner collection of a large number of weather reports can be accomplished within a very few minutes. By a series of relays from circuit to circuit it is then possible to disseminate this information very widely.

Each group of from 20 to approximately 40 stations is termed a "circuit." On each "circuit" the several stations transmit their reports in definitely established sequence. Because of strict time limitations each station must be ready to transmit its report exactly on schedule.

(*a*) It is essential that reports be perforated and that automatic transmission be utilized in the primary transmission of the reports in all sequence collections. If an error is made in perforation, the mutilated tape should be discarded and the report reperforated. Only perfect tape should be utilized for transmission on the circuits.

(*b*) For the national distribution of meteorological information on schedule "A", the national communication system will be considered as two networks—the eastern network, consisting of circuits 1, 2, 3, 4, 5, 6, 7, 10, 11, and 25, and the western network, consisting of circuits 9, 12, 13, 14, 15, 16, 23, and 24.

(*c*) Stations will enter all sequence collections in the proper order and 5 seconds will be the maximum allowable interval between reports; if any station fails to begin typing its report within 5 seconds after the scheduled starting time, or within 5 seconds following the preceding report, the next scheduled station will transmit and the

tardy station will then await completion of transmission by the station scheduled to appear last in sequence, thereafter transmitting report, available schedule time permitting.

(2) *When transmitted.*—The collection of hourly weather reports into sequence will be accomplished simultaneously on all originating circuits starting at 30 minutes past each hour. Collection will be completed within the time allotted in the detailed schedules. The time allotted varies on each circuit due to the different number of stations reporting. On all circuits, however, 10 seconds are allotted for each station to report in the sequence. It is necessary that all sequence collections be completed during the time allotted in order to permit relays to start promptly.

(3) *Transmission procedure.*—(*a*) The hourly weather sequence collection on each circuit will be headed by the time (24-hour clock system, Eastern Standard Time), followed without space by the letter "E", for example:

7:30 PM, EST—1930E

(*b*) The station first listed will start the sequence collection by the transmission of one letters shift, one carriage return, five line feed impulses, the time (see (3)(*a*) above), one carriage return, and one line feed impulse, followed by its report, and will then transmit one letters shift, one carriage return, and one line feed impulse following the report.

(*c*) Each succeeding station will type its report followed by one letter shift, one carriage return, and one line feed impulse.

(*d*) If more than one report is transmitted by any station, each will be separated by one letters shift, one carriage return, and one line feed impulse, the last report to be terminated by the transmission of one letters shift, one carriage return, and one line feed impulse.

Example of complete hourly sequence, including supplementary 3-hourly data:

1130E
KC N E9⊕11/2R 027/51/49↖17/960/ 808 50033
LW 15⊕3R—F— 027/51/50↑↖16/960/ 805 50055
TMH SPL E45⊕/⦶8TRW— 058/55/36←↖6/969/ 000 52069
CA ⊕/6K— 058/65/42↑↖25+/970/ 903 02096
ST ⊕/7 64/40↑↖23—/ 001
LS C —⊕/4K— 119/63/41↑↖22+/987/ 400 00700
CD —⊕/6K— 142/65/45↑↖16/994/ 402
EF —⊕/6K— 156/64/41↑↖14/998/ 402 01099

NU ⦶/5K— 163/59/39↖21/999/ 102 07097
TH —⦶/8 173/65/37↑↖15/004/ 303
ID C ⦶/6H 183/61/39↖8/006/ 300 03096
MV —⦶/3HK— 64/36↖11/ 102
TRM —⦶/4H 203/59/34↖10/011/ 403
DY C ○5K— 210/58/31↖11/014/ 302 00599
CO C ○3K— 230/56/33←↖10/019/ 402 00196
HA ○4H 244/45/29←12/021/ 403
CV C —⦶/4H 251/44/26↖10/024/ 103 00999
AX C ○7 251/45/26←↖7/024/ 403
CM ○4K— 237/54/35↙7/021/ 202
TEZ ○4K— 254/47/28←↙5/024/ 402
PT N ○11/4VK 240/46/24←↙5/021/ 300
BQ ○ 251/44/22↘9/021/ 102
RF ○6H 244/42/26←5/021/ 102
HX C ○7 247/41/24↘4/024/ 902
WMT ○ 247/43/14↓10/023/ 901
PG C ○6K— 240/43/25↓↘10/023/ 901
LG C —⦶/45⦶ 220/43/25↓15/017/ 903 10199
NK C ○ 224/43/24↓↘22/018/FEW CU 5THSD/
902 10097
WM 50⦶ 224/44/24↘15/018/ 902 10077
OM ○7 056/44/27↓7/029/ 101
PK ○4K— 227/58/32↖10/020/ 138
CO C ○4K—H 200/63/33↑3/011/ 300
WR ○5K— 63/42↙3/ 101
LV C ○6H 183/65/35↑↖5/007/ 300
TUW ○5K— 210/63/33↑9/014/ 300
HI ○11/2K— 213/62/34←4/015/ 000
KN ○3/4K 220/60/38↑3/016/ 000
EK ○7 247/44/35C/020/3K NE/ 000
MR ○8 240/47/29←↙3/022/ 000
FZ ○7 244/48/30C/023/ 000
TFD ○ 46/29↑1/ 902
WA C ○4K— 251/46/29↓↙7/026/ 003
PCE ○6H 43/27↘6/ 000

(4) *Late reports.*—(*a*) Should the hourly weather report be delayed in receipt so that an accurately perforated tape cannot be prepared in time to be sent in the station's usual place in the sequence, nothing will be transmitted, and the station will transmit the report in the first available time on the schedule.

(*b*) If the late report is scheduled for a radio broadcast, it will be preceded by the letters "PDW" and the time of the sequence. Example:

PDW 1330E WA C O 193/48/25↘18/009

The report will be preceded and followed by one letters shift, one carriage return, and five line feed impulses.

(*c*) If the report is not scheduled for a radio broadcast, it will be preceded by the letters "DDW" and the time of the sequence. Example:

DDW 1330E KN O 207/57/28→↗8/012

The report will be preceded and followed by one letters shift, one carriage return, and five line feed impulses.

c. Special weather reports.—(1) *General.*—A period has been allotted in the National communication system, schedule "A", for the collection of Special Weather reports in sequence order, and their relay to adjacent circuits. There will also be times when a station will send a Special Weather report at some time other than during the sequence collection. The transmission procedure for both cases is given in a separate paragraph below. For additional general information, see *b* above.

(2) *Sequence collection of special weather reports.*—(*a*) *When transmitted.*—The collection of special weather reports into sequences will be accomplished simultaneously on all originating circuits on the hour, and ending before the sixth minute. It is not expected that a Special Weather report will be prepared and entered in the sequence unless required by the provisions of section II.

(*b*) *Transmission procedure.*

1. The sequence on each circuit will be started by transmission of the first station report (or station identification). No sequence identification is necessary.

2. The station first listed will start the sequence collection by the transmission of one letters shift, one carriage return, and five line feed impulses, followed by its report or station identification (if no report is on hand). In case a report is transmitted, the report will be followed by one letters shift, one carriage return, and two line feed impulses; if no report is on hand, the station identification will be transmitted followed by one letters shift and two spaces.

3. At succeeding stations, if a special weather report is on hand for transmission, the following procedure will be used: Transmit one letters shift, one carriage return, two line feed impulses, station report, one letter shift, one carriage return, and two line feed impulses. At succeeding stations, if no special weather report is on hand for transmission, the following procedure will be used: Transmit station identification, one letters shift, and two spaces. If more than one special weather report for the same station is on hand for transmission, the latest report will be transmitted in the sequence collection.

4. If more than 18 consecutive stations enter the sequence without transmitting a special report, the eighteenth station will transmit one letters shift, one carriage return, and one line feed impulse in lieu of the two spaces normally transmitted.

Example of complete special weather report sequence collection:

KC LW TMH CA ST CD EF NU
TH ID MV TRR DY CO HA
CV AX
CM TEZ PT BQ RF HX WMT
PG LG NK WM OM PK CC
WW XFO WR
TLV TUW HI KN EK MR FZ
TFD WA
TAY SPL 075OC E30⊕R— 56/45 ↑ 18/PCPN
VERY LGT
TWY
TAI SPL 0758C 2⊕5F— 25/25 ↓ 16
AN

5. If reports from more than one location are transmitted by any station, or if identification for one station is followed by report from another, or vice versa, reports and/or identifications will be separated as described in *c*(2)(*b*) above.

6. Should conditions warrant a special weather report at the time of the hourly weather report sequence collection, the same procedure as though it were a Regular Hourly report is used. The word "SPL" will follow the call letters of the station, but be separated therefrom by one space.

Example: See third station in hourly sequence example in *b*(3)(*d*) above.

(3) *Transmission of special weather reports out of sequence.*—(*a*) Special weather reports may also be transmitted in any other available Star schedule as shown in the national communication system, schedule "A."

(*b*) When special weather reports are transmitted out of sequence, the following procedure will apply: Transmit one figures shift impulse, five bells, one letters shift impulse, one carriage return, five line feed impulses, station designator, classification of report, SPL, time on 24-hour clock with local time zone designation, weather report, one letters shift, one carriage return, and five line feed impulses.

Example: LS N SPL 0655C ⦶/2K— 132/48/ 33 ↑ 8/991

d. Dispatch Notice to Airmen (NOTAMS).—(1) *Definition.*—The term "Notice to Airmen" (NOTAM) is defined as notification of pilots and others directly concerned with air navigation of changes that affect the normal status of radio facilities and other aids to air navigation, the types of service they render, and their use by pilots.

The subjects which may be included in Notices to Airmen are the commissioning, decommissioning, and test operation prior to commissioning of an aid to air navigation, including radio facilities, beacon lights, airports, intermediate landing fields, obstruction lights, etc.; the failure of such facilities, and their restoration to service; development of or correction of surface conditions which render all or a portion of an airport or landing field unsafe for use; the change in type or relocation of an aid to air navigation; or, in general, anything pertaining to the air navigational system which affects the use of the system.

(2) *When transmitted.*—A dispatch Notice to Airmen (NOTAM) will be transmitted as soon as practicable, describing the failure or return to operation of any radio aid to air navigation and of any other aids to air navigation (beacon lights, obstruction lights, landing T, wind cones, etc.), the development and correction of unsafe landing field conditions, and, in general, the unanticipated abnormal condition or operation of aids.

A dispatch Notice to Airmen will be transmitted as soon as practicable, describing the failure or return to operation of radio facilities which have been made the subject of a flash notice. If the facility has been restored to operation before the NOTAM has been transmitted, both the failure and return to operation will be described in the NOTAM. Example:

NOTAM RACOM————(station identification)
RANOT
1035E RAGOK 1055E 251100

Changes in any radio, lighting, or field aid, which have been anticipated and advertised by an advance Notice to Airmen, either written or in dispatch form, will be confirmed at the station concerned by a brief NOTAM to all concerned when the change is made effective. Ordinarily, such changes will be advertised to become effective on the fifteenth or last day of the month in order that a confirmation can be published in the written notice, after receipt of dispatch NOTAM confirmation, on the sixteenth or first day of the month.

(3) *Distribution.*—Dispatch Notices to Airmen will be transmitted on schedule "A." They will be relayed to all stations within a radius of 300 miles which broadcast weather reports originating at the station from which the dispatch Notice to Airmen is sent. It is the responsibility of the operator in charge of each station to prepare and post in his station, and keep corrected to date, a list of the points to which dispatch NOTAMS from his station are to be addressed. Teletype and radio relay station personnel will relay dispatch NOTAMS to the specific stations included in the address for which they have taken a number and given an acknowledgment to the transmitting station. It is not the responsibility of the relay station operator to see that the transmitting station has addressed the dispatch NOTAM to the proper destinations.

(4) *Composition of dispatch Notices to Airmen.*—Dispatch Notices to Airmen consist of four component parts: the preamble, address, text, and signature. Each of these four parts will be treated in a separate paragraph below.

(*a*) *Preamble.*—The preamble of a dispatch Notice to Airmen consists of the identifications of the stations to which the dispatch is sent, the traffic classification letter, serial number, the identification of the sending station, and the name of the station where the dispatch originates.

1. Destinations.—The identifications of the stations to whom the message is being sent will be the call letters (teletype identification) of the stations whose names appear on the list of the points to which the message is to be sent (see (3) above), provided that these stations are on the same circuit as the sending station. Should any of these stations be on a circuit other than the one on which the sending station is located, the call letters of this station

would not appear in the preamble; in its place would appear the call letters of a relay station which, after receiving the message from the sending station, would relay it to the station for whom it was intended. The call letters of the station for whom the message was intended would be placed in the *address*. If the message was not to be delivered to the relay station, the call letters of the relay station will not appear in the address, but in its place would appear the call letters of the station to whom it is relaying the message. If the message is intended for the relay station, then, in the address, the call letters of the station to whom the message is being relayed will follow the call letters of the relay station.

2. Classification letter.—Dispatch Notices to Airmen (NOTAMS) will be accorded priority (P) classification on the teletype and radiotelegraph circuits of the Civil Aeronautics Administration.

3. Serial number.—Dispatches will be numbered serially at each originating station commencing with number 1 at midnight, Eastern Standard Time (or any time after midnight that the first dispatch is sent). The number series will continue through each 24-hour day with a separate set of numbers to each station or relay point to which numbered traffic is numbered. Only one set of numbers will be maintained with each station communicated with, regardless of the various channels of communication available.

The serial number will be transmitted immediately following the traffic classification letter with no space intervening.

Numbers will be marked off the number sheet (Form 407) immediately after receipt or transmission of a dispatch for record purposes and to detect any missing numbers.

When the serial number is not the same to more than one station, the dispatch classification and number will follow each destination. Example:

BU P2 FV P7

When the serial number is the same to more than one station the dispatch classification and number will follow the destinations. Example:

AG NK AZ P5

When two or more numbers are given to one station for relay purposes, they will be separated by a dash, using only the first and last number of the series. Example:

FV P3-7

4. Sending station.—The identification of the sending station will be made by using the teletype call letters for the station. Example:

WA

5. Originating station.—The identification of the originating station will be the name of the station (city or town) where the station is located. The name will be written out in full and if it is believed that the receiver will have difficulty in determining the state where the station is located, the authorized abbreviation of the state will be sent after the names of the originating station, separated therefrom by a space. The name of the originating station will always be written as one word. Example:

WASHINGTON

Example of complete preamble:

BU P2 FV P7 WA WASHINGTON

(*b*) *Address.*—The address will be the name of the city or town (teletype identification) where delivery will be made. The order of the stations in the address will be the same as in the preamble.

(*c*) *Text.*—To facilitate the sending, handling, and filing of Notices to Airmen (NOTAMS) the subjects which may be included in Notices to Airmen have been divided into the three classes:

RACOM—Radio and communication facilities.
FILLI—Field and lighting facilities.
MISEL—Miscellaneous, such as practice bombing, barrage balloon flying, etc.

The first two words of the text will be NOTAM RACOM, NOTAM FILLI, or NOTAM MISEL, depending on the subject. After these two words, the condition will be described, using authorized abbreviations and phrase contractions whenever possible. Care will be exercised in drafting NOTAMS to avoid use of a terminology which might tend to confuse the reader. Such phrases as "Use with caution,"

"Unreliable," etc., are strong terms and actually indicate that use of the facility in question should be avoided except as a last resort.

Each NOTAM pertaining to RACOM, FILLI, or MISEL will include *all current information* regarding irregularities in the class of aids described by the NOTAM concerning a specific location. *It is necessary that each NOTAM be complete in itself so far as that class is concerned.* The new information will be shown first, followed by one space, one plus sign (+), one space, and then the old data.

The text is completed by a six-figure date-time group which is made up as follows:

The date group is a two-digit group indicating the day of the month. If the number is less than 10, it will be preceded by a zero. The time of origin group immediately follows the date group; the first two digits of it indicate the hour from 00 (midnight) to 24 (midnight); the last two digits indicate the minutes after the hour—from 00 to 59, inclusive. Below is an example of a date-time group for the seventh day of the month at 10:30 PM—072230. The date-time group indicates the date and time the message is filed with the operator or the time at which he, the operator, writes it if he is the sender of the dispatch.

(*d*) *Signature.*—Dispatch Notices to Airmen originating at a military station or post will use as a signature the last name of the commanding officer of the station or post.

(5) *Transmission procedure.*—(*a*) All dispatches will be sent by use of a perforated tape and automatic transmission equipment.

(*b*) Delivered copies of dispatch Notices to Airmen (NOTAMS) on page model teletype writers will have a minimum length of approximately 5½ inches. To secure this uniform size, the procedure herein described will be followed when perforating dispatch traffic for transmission.

(*c*) Perforate one letters shift impulse and one carriage return impulse followed by one figures shift and one plus (+) sign. Then one letters shift, one carriage return, and eight consecutive line feed impulses will be perforated, followed by the preamble. One letters shift, one carriage return, and two line feed impulses will then be perforated; then the address; then letters shift, one carriage return, and two line feed impulses, followed by the text. One letters shift, one carriage return, and two line feed impulses will be perforated at the end of each line of 65 to 76 characters and spaces throughout the text. After the date-time group, one letters shift and two line feed impulses will be perforated, followed by the signature provided it can be accommodated within the number of functions available to complete the line. Otherwise, one letters shift, one carriage return and two

line feed impulses should be perforated, followed by the signature. Following the signature, the perforator tape will be completed by the cutting of one letters, one carriage return, and sufficient line feed impulses to bring the total number of line feed impulses in the dispatch to 34. Following the thirty-fourth line feed impulse, one figure shift impulse will be cut, followed in order by a plus (+) sign, one bell signifying end of dispatch, one letters shift, one carriage return, and one line feed impulse.

(*d*) If there are 34 or more line feed impulses utilized during the transmission to and including the signature, at least six line feed impulses will be transmitted before the final plus sign is struck.

(*e*) When dispatches are transmitted in a series without interruption, the procedure between successive dispatches will be amended to eliminate transmission of one plus (+) sign and bell impulse as follows:

Following the thirty-fourth line feed impulse, one figures shift impulse will be sent, followed by a plus (+) sign and followed in turn by one letters shift, one carriage return, and eight consecutive line feed impulses, followed by the preamble of the next dispatch.

(*f*) An example of a dispatch Notice to Airmen as it would appear on a page model teletypewriter follows.

+(8 line feed impulses)
LQ P1 BU P1–3 DG DAGGETT
LQ BU KI AB
NOTAM RACOM DG RAGOK 242345 250015
SIGNATURE
+(20 line feed impulses)

Note that the time of resumption of operation in the foregoing NOTAM is indicated on the 24-hour clock system with the date shown in a six-figure time group, in addition to the usual six-figure date-time group indicating the time that the message was written. It will not be necessary to show the date if the aid is restored to service on the date indicated by the six-figure date-time group.

e. Flash Notices.—(1) *When transmitted.*—A Flash Notice will be transmitted as soon as possible after the failure or return to operation of a *radio* aid to air navigation. When a radio or broadcast facility is to be shut down for maintenance purposes and ½ hour advance notice naming a specific time is given by dispatch NOTAM, a Flash Notice will not be transmitted at the time the shutdown is actually made. A Flash Notice will be transmitted immediately when service is restored. The Flash Notice does not displace the dispatch NOTAM, but is intended to convey the information to those con-

cerned with less delay than is encountered in the transmission of dispatch NOTAMS. Flash Notices will be transmitted at any time that the circuits are idle without regard to schedules. A Flash Notice will be transmitted from the point of origin to all points which require the information (see (2) below) if transmission cannot be accomplished within 30 minutes from the time of origin of the Flash Notice.

(2) *Distribution.*—The Flash Notice will be relayed on schedule "A," to all stations within a radius of 300 miles which broadcast weather reports originating at the location of the radio aid to which the Flash Notice pertains. Teletype and radio relay station personnel will post a list of stations to which Flash Notices received by them are to be relayed, and will be held responsible for the prompt relay of the Flash Notices when received.

(3) *Composition.*—A Flash Notice consists of three general parts: the call letters of the reporting station, the phrase contractions, and the time of failure or return to operation (24-hour clock system and authorized time zone abbreviation). Example:

WA RANOT 1620E

Each Flash Notice issued concerning a specific location will be complete in itself.

(4) *Authorized phrase contractions.*

APTNO—Failure of airport tower radio facilities upon information furnished by the airport manager or the control tower operator.

APTOK—Return to operation of airport tower radio facilities upon information furnished by the airport manager or control tower operator.

ATNNO—Attention signal not operating.

BRONO—Failure of a voice feature of any radio station including radio broadcast (class B), the voice feature of a medium power range (class MRA or MRL), the voice feature of a low power range (class ML), or the voice feature of a radio marker beacon (class M).

BROOK—Return to operation of a voice feature transmitter reported not operating by transmission of BRONO.

FANHD—Ultra high frequency fan type marker has been reported not heard.

FAFON—Ultra high frequency fan type marker which was reported as not being heard by FANHD has been found operating.

FANOT—Ultra high frequency fan type marker is not operating.

FAROK—Return to operation of the ultra high frequency fan type marker reported not operating by FANOT, or reported not heard by FANHD.

POWNO—Power supply failure.

BOWOK—Return of power supply reported as failed by POWNO.

RANOT—Failure of a full power range (class RA or RL), the directional features of a medium power radio range (class MRA or MRL), the directional features of a low power range (class ML), and the radio marker feature of a radio marker beacon (class M).

RAGOK—Return to operation of a radio aid reported not operating by RANOT.
RARAU—Radio range appears unreliable.
RCVNO—Receiving facilities are not operating.
RCVOK—Receiving facilities have resumed operation.
ZONHD—Ultra high frequency station location marker has been reported not heard.
ZOFON—Ultra high frequency station location marker which was reported as not being heard by ZONHD has been found operating.
ZONOT—Ultra high frequency station location marker is not operating.
ZOHOK—Return to operation of the ultra high frequency station location marker reported not operating by ZONOT or reported not heard by ZONHD

(5) *Transmission procedure.*—(*a*) All Flash Notices will be sent by use of a perforated tape and automatic sending equipment.

(*b*) The tape will be perforated by cutting one figure shift impulse followed by five bell impulses, one letters shift impulse, one carriage return, and five line feed impulses followed by the Flash Notice. Example:

WA BRONO 1620E

The Flash Notice will be followed by one letters shift, one carriage return, and five line feed impulses.

(*c*) The Flash Notice indicating resumption of operation will be transmitted in the manner prescribed for the transmission of the Flash Notice concerning the failure.

(*d*) The phrase contraction without the time group (RANOT, BRONO, ZONOT, RARAU) concerning the failure of a radio aid will be added to and handled as part of each weather report which originates at the location of the inoperative aid during the period of the failure, and while the aid is inoperative for maintenance purposes. It will be placed at the end of the report after all the items which comprise the report, separated by one space. Example:

WA C E80⊕/⏀ 207/45/30↓18 BRKS 10VC/
810/52096 RANOT

When the inoperative aid has been returned to operation the phrase contraction which has been added to weather reports concerning the failure will be discontinued. The phrase contraction indicating resumption of operation will not be transmitted as part of a weather report. The absence of phrase contractions from a weather report will indicate that the services were operating when the weather report was transmitted.

In exceptional cases only, particularly in cases of course displace-

ments, remarks may be added to a Flash Notice stating briefly any irregularity that exists. Example:

WA RAGOK RARAU CRSS DSPLCD 1647E

f. Notices to Airmen for National Distribution (*NADIS*).—(1) *When transmitted.*—When any changes of a permanent nature are made, such as relocation, establishment, or discontinuance of radio range, communications station, control towers, airports, etc., or when it is known that a temporary condition or irregularity will exist for a period of 10 hours or more, a dispatch Notice to Airmen for National Distribution (NADIS) will be sent on schedule "A" describing such change or irregularity. These dispatches are collected only in sequences which will be accomplished on all originating circuits beginning at the start of the fifteenth minute after the hour to the end of the nineteenth minute, except during the hour 1600E, when the period is being utilized for circuit lineup (CLU). The Notice to Airmen for National Distribution (NADIS) will be transmitted in the sequence immediately following the issuance of the notice, and it will not be repeated hourly.

(2) *Composition.*—(*a*) The dispatch Notice to Airmen for National Distribution will consist of the region number in which the aid is located, station identification of transmitting station, and the text of the dispatch followed by the date-time group. The text will be drafted following the instructions given in Notices to Airmen (NOTAM), *d*(4)(*c*) above. The dispatch will conform to the following example:

5 KC NOTAM FILLI DISABLED ACFT
CNTR OF FLD MRKD 021257

(*b*) A NADIS NOTAM either RACOM, FILLI, or MISEL is required to cancel a NADIS NOTAM of the same classification. The phrase contraction CANOA (cancel previous NOTAM) will be included in the text of all NOTAMS that cancel or supersede a current NOTAM of the same class. The phrase contraction CANOA together with the date of the NOTAM to be canceled will immediately precede the date-time group. Example:

4 WF NOTAM FILLI SHEPPARD FLD MOWING
COMPD CANOA 9 131010

(3) *Transmission procedure.*—(*a*) The sequence collection on each circuit will be started by the station which normally begins the

hourly weather sequence collection by the transmission of one letters shift, one carriage return, five line feed impulses, followed by the phrase contraction NADIS, one space, circuit number, one space, time and zone designator, one carriage return, and two line feed impulses.

(*b*) At stations where two or more schedule "A" circuits are common to one location, the Notice to Airmen and/or identification will be entered on the lower numbered circuit only, in the same sequence position as for the hourly weather report.

(*c*) The following procedure will be used by each station which has a Notice to Airmen (NADIS) on hand for entry in the sequence collection (NTAC). Transmit one letters shift, one carriage return, two line feed impulses, figure shift, plus sign (+), letters shift, five line feed impulses, the notice, one letters shift, one carriage return, five line feed impulses, figures shift, plus sign (+), one bell signal, letters shift, one carriage return, and two line feed impulses. After each line of 65 to 76 characters and spaces throughout the text, transmit one letters shift, one carriage return, and two line feed impulses.

(*d*) If there are no Notices to Airmen for National Distribution on hand at a station, the station will transmit station identification, one letters shift and two spaces.

(*e*) If more than eighteen consecutive stations enter the sequence without transmission of a Notice to Airmen, the eighteenth station will transmit one letters shift, one carriage return and one line feed impulse in lieu of the two spaces normally transmitted.

(*f*) When two or more Notices to Airmen (NADIS) are transmitted in a series without interruption, the procedure will be changed to eliminate the transmission of the bell and one plus sign between two successive messages.

(4) *Relays of NADIS.*—The relays of NADIS will be accomplished immediately following the completion of the collection. The relay will be started promptly at the beginning of the 20th minute of each hour (except 1600E) and ending before the 28th minute. The word "end" will be transmitted on all circuits following completion of each group of transmissions. When a station identification appearing in the sequence collection is not followed by a Notice to Airmen, the station identification will be deleted from the initial relay of the group transmission by the responsible relay station. There will undoubtedly be periods when there are no Notices to Airmen for National Distribution on hand at relay stations, and in cases of this

kind, the relay station shall perforate and enter in the relay schedules a report utilizing the following procedure. Example:

NADIS 1 2 3 6 1515E FINO L6

g. Administrative dispatches.—Administrative dispatches will consist of five parts: the preamble, address, addressee, text, and signature.

(1) *Composition of preamble.*—See Notices to Airmen, *d*(4)(*a*) above, with the exception that the classification letter may be either "P," "D," or "W," depending on the urgency of the message. When sending a dispatch to a large group of stations, the phrase contractions ALL STN (number), ALL CKT, ALL SXN, or ALL CAA (number) may be used in the preamble and address in place of the identifications of the individual stations. Examples:

ALL STN 4 DI FV FTWORTH (number after ALL STN is the region number)
ALL CAA 4 W3 FV FTWORTH (number after ALL CAA is the region number)
ALL CKT 9 DI KC KANSASCITY
ALL WD AB SXN P1 KO KANSASCITY

(2) *Composition of address.*—See Notices to Airmen, *d*(4)(*b*) above.

(3) *Composition of addressee.*—The addressee of a dispatch is the individual office, or group of individuals or offices, or both, located at the address to whom the dispatch will finally be delivered.

(*a*) Dispatches intended for delivery only to the operator in charge of communication station will not carry an addressee.

(*b*) The abbreviation STN (station) will be utilized to indicate delivery to the operator in charge, or acting in charge, of a station when one or more other addressees are indicated and the dispatch is also intended for delivery to the person in charge of the communication station.

(*c*) Dispatches intended for delivery to a specific group (ALL STN, ALL CAA, ALL CKT, or ALL SXN) will not use an addressee, unless other addressees are to be included.

(*d*) The addressee, when used in a dispatch, will make up the first word, or words, in the text but will be separated therefrom by a period (.).

(*e*) The surname will be utilized to indicate delivery to an individual not regularly attached to the station addressed. If there are offices other than the authority at the address shown, the word CARE and the abbreviation of the office where the addressee can be reached should also be shown.

(*f*) All dispatches to regional offices will carry the addressee CAA and routing to section concerned will be made within the regional office.

(*g*) Field offices of the Air Carrier Inspection Service not located at regional headquarters will be indicated by the abbreviation INSP.

(*h*) Field offices of the General Inspection Service not located at regional headquarters will be designated by the abbreviation AERO.

(*i*) Dispatches may be addressed for information of offices or individuals by using the abbreviation INF (information), followed by those addressees to whom the communication is being forwarded for their information only.

(*j*) Examples of addressees follow. Addresses and addressees are shown on the same line for convenience. Actual transmission will conform with (5)(*c*) below.

Address	Addressee	For delivery to—
CJ	(No addressee)	Operator in charge or acting in charge.
WA	CAA	Civil Aeronautics Administration, Washington, D. C.
CG	CAA	Chicago regional office.
OA	INSP	Air Carrier Inspection Service, suboffice at Oakland.
OA	AERO	General Inspection Service, suboffice at Oakland.
WA	WBO	U. S. Weather Bureau City Office.
FV	AWO	U. S. Weather Bureau Airport Station.
CG	ATC	U. S. Airway Traffic Control Center.
BF	RANDOLPH	Individual not regularly attached to the station addressed where there is no other office.
FV	LITTLE CARE AWO	Individual not regularly attached to the station addressed and delivery to be made by other than operating personnel.
CG	EDWARDS CARE STN.	Individual not regularly attached to the station addressed where there are other offices and delivery is to be made by operating personnel.

Address	Addressee	For delivery to—
WA	NAVY	Delivery to Navy Department Air Service Headquarters. NOTE.—The use of NAVY, COAST, and WAR is authorized when arrangements have been made to deliver communications to certain acceptable addresses.
LG AG CG KC FV BU SA HQ	ALL CAA	All regional offices.
WA XN	CAA WA BROWN CARE STN XN	Multiple address dispatch showing a copy to be delivered to a person not regularly attached to the Austin station.
LG CG	CAA LG IFN CAA CG	Action to be taken by regional office, Newark; copy to regional office, Chicago, for information.
CG CJ	CAA WBO CG STN AWO CV	Chicago operator responsible for delivery to regional office and downtown Weather Bureau office, Chicago; Cleveland operator responsible for delivery to operator in charge and Airport Weather Bureau, Cleveland.

NOTE.—A dispatch to any one point may only carry one address regardless of how many offices or persons at that point are to receive a copy of the dispatch.

ALL CG KC SXN (No addressee) — All stations inclusive between the two given points on a circuit.

NOTE.—Addressees would be the operator in charge or acting in charge at the stations indicated. See note below with regard to the use of the word XCP.

ALL CKT 9 (No addressee) — All stations on one circuit.

NOTE.—ALL CKT, ALL SXN, ALL STN, and ALL CAA addresses may be used and notified when necessary by the word XCP to denote subtraction of any station or stations. Example: "ALL CKT 9 XCP WY AND JX." WY and JX will then receipt for and file the dispatch without further action. This procedure is necessary to insure complete number records of ALL CKT, ALL SXN, ALL CAA, and ALL STN dispatches at all points.

ALL STN1 (No addressee) — All stations within the First Region.

NOTE.—See note above.

ALL CAA1 (No addressee) — All Civil Aeronautics Administration stations in the First Region.

NOTE.—See note above.

(4) *Composition of text.*—The text should be drafted in a brief, concise form utilizing authorized abbreviations and phrase contrac-

tions where possible. When writing dispatches, particular attention should be given to the omission of all superfluous words. The words "of," "in," "the," "that," "by," "please," etc., can usually be omitted without obscuring the meaning of the text.

(5) *Composition of signature.*—(*a*) Administrative dispatches originating with communication station personnel should be signed with the initials of the operator in charge or acting operator in charge. If there is reason to believe that the recipient of a dispatch may not readily identify the sender by the initials, the last name of the sender will be utilized for the dispatch signature.

(*b*) The transmission procedure used is the same as given under Notices to Airmen (NOTAMS), *d*(5) above. Dispatches will be sent on schedule "A" by use of a perforated tape and automatic sending equipment.

(*c*) There follows an example of a dispatch as it would appear on a page model teletypewriter.

(8 line feed impulses)

```
LG  AG  W9  CG  W9-11  KC  W4  FV  W7-8  WA  WASHING-
  TON  LG  AG  CG  SA  HQ  KC  FV  BU
ALL CAA.  INDCD  RGNL  HDQTRS  AND  FLD  STNS  TSMTG
  DISS THAT SHOULD BE MLD.  UTILIZE MLS EVERY CASE
  PRACTICABLE  AND  ELMT  UNEC  WDS  FROM  DIS  TFK.
  THIS  OFFICE  WILL  DETAIL  INSP  TO  MONITOR  AND  CK
  DIS  RECORD  STN  FILES  170028
                                                  EFW
```

(14 lines feed impulses)

h. Service dispatches.—(1) *Purpose.*—A service dispatch is used to request a correction or a verification of another dispatch, or to advise stations on other circuits of interruptions of communication facilities.

(2) *Composition.*—(*a*) *Preamble.*—See Notice to Airmen, *d*(4)(*a*), above, with the following exceptions: The classification letter of a service dispatch will be the same letter as the dispatch to which it refers, except that in exceptional circumstances service dispatches relative to "D" traffic may be given the "P" classification and service dispatches relative to "W" traffic may be given the "D" classification. Also, the office of origin is omitted and in its place the letter group SUC is transmitted. Example:

CG WZ CV SUC

(*b*) *Address.*—See Notice to Airmen, *d*(4)(*b*).

(*c*) *Addressee.*—The adressee is omitted in a service dispatch.

(*d*) *Text.*—The text will contain a sufficient description of the dispatch referred to in order to permit prompt and accurate identification of the dispatch concerned; the original dispatch may be referred to by serial number (without classification letter) only if no relay is involved. The date-time group may be employed as a reference in service dispatches provided sufficient additional description is included.

(*e*) *Signature.*—The signature of a service dispatch will be the call letters of the station where the service dispatch originated.

(3) *Correcting errors.*—Service dispatches correcting errors in relay traffic will be addressed to the station that made the inquiry, and to the destination of the dispatch referred to, and not to the stations along the line through which the original dispatch was relayed.

(4) *Transmission procedure.*—See Notices to Airmen, *d*(5) above.

i. Servicing transmitted traffic.—(1) The time and date of filing will be stamped or written on each dispatch accepted by the operator for transmission.

(2) The following data relative to the transmission of a dispatch will be stamped or written on the copy received for transmission:

(*a*) The classification letter.

(*b*) The serial number or numbers.

(*c*) The identification of the station or stations to which the dispatch was sent.

(*d*) The time transmission was completed (24-hour clock time, or authorized time stamps, with 12-hour a.m. and p.m.).

(*e*) The initials of the operator in longhand who transmitted the dispatch, followed by a slant (/), followed by the initials of the operator who performed the daily traffic check.

(3) If desirable, stations equipped with page teletypewriters may affix servicing data to the transmitted copy, attaching such copy to the copy received for transmission.

(4) The transmitting operator will be responsible for obtaining acknowledgments of receipt from all stations to which he transmitted the dispatch.

j. Servicing of received communications.—(1) The following data will be written or stamped on all received dispatch traffic, preferably in the upper right hand corner.

(*a*) The station name.

(*b*) The word RECEIVED.

(*c*) The time of receipt (24-hour clock system, or authorized time stamps with 12-hour AM. and PM.).

(*d*) The month, day, and year.

(*e*) The initials of the receiving operator, in longhand.

(2) All meteorological data will be date stamped on the right hand margin on each section of tape.

k. Emergency transmissions.—(1) *"SSS" communication.*—(*a*) *When transmitted.*—An SSS communication will be sent relative to an emergency which involves the safety of life and property. The class SSS traffic is accorded priority over all other transmissions and, therefore, is sent at any time regardless of schedule. SSS communications are transmitted on schedule "A."

(*b*) *Transmission procedure.*—Open the circuit for 5 seconds by means of the break key which is located on the front left of the page model teletypewriter. Then transmit a bell signal consisting of three bells, space, three bells, space, three bells, followed by one letters shift, one carriage return, and five line feed impulses. Then transmit letter S, space, letter S, space, letter S, space, identification of station addressed, space, the letters DE, space, the identification of the sending station, space, and then proceed with the communication. Example:

S S S ZH DE TV NC12345 BCFT D1650C ENRT ZH FROM EO PILOT DOE 3 PSGRS RPRTS UNAB ESTBL GND CTC HAS GAS FOR 15 MINS FLYING XAC PSN UNKNOWN PILOT ATTEMPTING LCT BARKSDALE FLD SHIP ON 3120

After each line of 65 to 76 characters and spaces throughout the message, transmit one letters shift, one carriage return and two line feeds.

(*c*) Transmission of the 3 3 3 bell signal and the letters S S S will constitute warning to all operating personnel to refrain from all transmissions not connected with the emergency until the circuit has been released.

(*d*) When the S S S traffic has been completed, the station which transmitted the S S S signal will release the circuit for normal operation by the following transmission:

> One figures shift, 5 bell signal, one letters shift, one carriage return, and five line feed impulses.

Then transmit CQ DE (station designator) followed by one letters shift, one carriage return, and two line feed impulses. Then transmit S S S CLEARED RESUME TRAFFIC followed by one figures shift, one bell signal, one letters shift, one carriage return, and five line feed impulses.

(2) *Emergency warning.*—(*a*) The procedure described in the instructions which follow are intended for application when aircraft equipped with facilities for radio transmission and reception are known to be in difficulties, such as when aircraft in flight are unable

to establish their position with respect to reference points on the ground, or are overdue at their destinations and no reports concerning their actual position can be secured.

(*b*) Information which becomes available at an airway communication station concerning an aircraft in difficulties should be transmitted (by interphone, telephone, telegraph, teletype or personal delivery) with the least possible delay to the class B (broadcast) airway communication station nearest the last reported position of the aircraft. The information to be transmitted will include identification and type of aircraft, points from and to which aircraft is being flown, time of last departure, last known position of aircraft, transmitting frequency, time of last radio contact with aircraft, total fuel supply on board when aircraft left the point of last departure, and any additional information pertinent to the circumstances.

(*c*) Upon receipt of the above information, the class B airway communication station will transmit an EMERGENCY WARNING for relay to all schedule "A" teletype circuits in the possible accident area. The possible accident area will be considered to include all radio range stations within a radius of 200 miles of the last reported position of the aircraft and all radio range stations which may have been used by the aircraft from the last point of departure to the last reported position of the aircraft. The class B station will determine which stations can be designated to perform a continuous range monitoring duties which will be required. The EMERGENCY WARNINGS will then be addressed to all of the stations selected to perform the continuous range monitoring duties.

(*d*) *Transmission procedure.*—The EMERGENCY WARNING will be transmitted in the following manner:

1. Transmit the S S S signal.

2. The words EMERGENCY WARNING DE———(call letters of the station where the transmission originates).

3. Teletype call letters of each station which is to perform the continuous range monitoring duties followed by the name (spelled in full) of the range station to be monitored by the individual stations.

4. The information covering identification and type of aircraft, points from and to which aircraft is flying, time of last departure, last known position of aircraft, transmitting frequency utilized by aircraft, and time of last radio contact with the aircraft.

5. The words MONITOR RANGES STP GUARD——— (frequency in kilocycles last utilized for transmission by the aircraft).

6. Any other information pertinent in the circumstances.

7. Termination of the S S S transmission.

8. Transmission will conform to the following example:

S S S EMERGENCY WARNING DE CO

DT	TOLEDO	WR	LOUISVILLE
TL	DETROIT	LV	SMITHSGROVE
VK	CLEVELAND	MV	DAYTON
CV	AKRON	LF	INDIANAPOLIS
CM	PITTSBURGH	EF	TERREHAUTE
HA	COLUMBUS	LF	LAFAYETTE
HI	CHARLESTON	YV	FORTWAYNE
KN	HUNTINGTON	FW	GOSHEN
TUW	CINCINNATI	GO	SOUTHBEND
		JK	NASHVILLE
		NA	SMITHVILLE

AR 17056 P39J ROUTE FROM PK NA 20/CFR VIA CC LV SO. 4495 D1124E NO RDO CTCS OVER 1 HR OVER DUE. 3 HRS TOTAL FUEL. NO FTHR IFN MONITOR RANGES STP GUARD 4495
CQ DE CO
S S S CLEARED RESUME TRAFFIC

(3) *Accident notice.*—(*a*) Information concerning accidents to aircraft which becomes available at airways communication stations will be transmitted (by interphone, telephone, teletype, telegraph, or personal delivery) with the least possible delay to the class B (broad cast) airway communication station nearest to the accident scene. The information will include identification and type of aircraft, points from and to which aircraft is being flown, name of pilot or pilots, total number of crew members, total number of passengers, brief description of accident, scene of accident, time or estimated time of accident, number of persons seriously injured and number of fatalities, time of last radio contact with the aircraft, and any other information relative to the accident.

(*b*) Upon receipt of the above information, the class B station notified will ascertain whether use of radio range facilities by the pilots may have had any bearing on the accident. If operation of radio

range facilities is known to have had no bearing on the accident or if aircraft did not have facilities for radio transmission and reception, no ACCIDENT NOTICE will be sent. If operation of radio range facilities had, or may have had, any bearing on the accident, the class B station will transmit an ACCIDENT NOTICE for relay to all schedule "A" teletype circuits in the accident area. The accident area will be considered to include all radio range stations within a radius of 200 miles of the scene of the accident and all radio range stations which may have been used by the aircraft while en route from the last point of departure to the scene of the accident. The class B stations will determine which stations can be assigned to perform the continuous range monitoring duties which are required and the ACCIDENT NOTICE will be addressed to the stations selected.

(*c*) The ACCIDENT NOTICE will be transmitted in the following manner:

1. Transmit the S S S signal.

2. The words ACCIDENT NOTICE DE——— (call letters of station where transmission originates).

3. Teletype call letters of each station which is to perform the continuous range monitoring duties followed by the name (spelled in full) of the range station to be monitored by the individual station.

4. The information covering a brief description of the accident, scene of accident, and time or estimated time of accident.

5. The words MONITOR RANGES.

6. Any other information pertinent in the circumstances.

7. Termination of the S S S transmission.

8. General form of message will conform to example shown under EMERGENCY WARNING.

l. *Dispatch reception*.—(1) All numbered traffic will be acknowledged. The receiving operator will be responsible for transmitting prompt acknowledgment. Acknowledgments should not be sent until the receiving operator has read the dispatch and is positive it is correct insofar as he is able to determine.

(2) Upon receiving a numbered communication, the receiving station will send an acknowledgment consisting of the following parts:

(*a*) Identification of station addressed.

(*b*) The letter R (received) followed by the serial number or numbers assigned to the receiving station.

(*c*) Identification of sending station. These parts will be transmitted in the order listed.

Examples:

CG	R1	GO				Straight Number dispatch.
CG	R3–5	GO				Serial numbers of the first and last communications sent in an unbroken series.
CG	R1	ALL	CKT	GO		ALL circuit dispatch.
CG	R1	ALL	SXN	GO		ALL section dispatch.
CG	R1	ALL	STN	3	GO	ALL region stations dispatch.
CG	R1	ALL	CAA	3	GO	ALL Civil Aeronautics Authority stations Region 3 dispatch.

(3) ALL SXN, ALL CKT, and other dispatches transmitted to a group of stations will be acknowledged in weather sequence order on schedule "A."

(4) Acknowledgments for any class of traffic may be transmitted within the period allocated to any other class traffic, provided that the circuit is not required for the transmission of traffic of the class scheduled for that period. Acknowledgments may be sent by direct keyboard operation, without the use of a perforated tape.

m. Errors.—(1) *Perforator tape.*—All meteorological data with the exception of forecasts and 3- and 6-hourly map reports will be transmitted from prepared perforator tape which should be carefully checked for errors against the typed or written copy. When an error is made, the imperfect tape should be discarded and a new perfect tape prepared for transmission.

If an error is made when perforating tape for other than meteorological transmission but including forecasts and 3- and 6-hourly map reports, the operator may back space to the error, erase it by means of the letters shift impulse, and proceed with the balance of the tape perforation. As the same amount of time is required for transmission of the letters shift impulse as for any other impulse or character, not more than five superfluous letter shift impulses will be permitted for each 100 characters and functions transmitted. If corrections of errors will exceed this ratio, the tape should be discarded and new tape prepared.

(2) *Direct keyboard operation.*—If an error is made and noticed immediately during direct keyboard operation on the teletype circuit, the operator will teletype XXX, then repeat the word or group in which the error occurred, and proceed with the balance of the teletype transmission.

Example:

NOW IS THE TIEXXX TIME FOR ALL GOOD, etc.

(3) *False signals.*—To avoid transmission of false signals to tele-

typewriter circuits, full use should be made of the facilities provided on the machine to make the keyboard inoperative except when manual transmission is actually in progress. Some tape machines are provided with a key lever locking bar which should be used when available. All page type machines have a key lever which should be kept in the REC position, except when manual transmission is actually in progress.

n. "Q" signal communications.—(1) *Use.*—"Q" signal abbreviations have been devised to make it possible to ask questions, answer questions, or send advice by the use of three- or four-letter groups instead of writing the question or answer in full. Each "Q" signal abbreviation has a definite meaning.

(2) *Composition.*—A "Q" signal communication will consist of the call letters of the station addressed, the appropriate "Q" signal abbreviation, any additional information required (this will be the information necessary to fill the blank spaces in the English meaning of the "Q" signal), and finally the call letters of the sending station. Example:

WA QXKQ W17 UV Q DATE CV

(3) *Transmission procedure.*—"Q" signal abbreviations may be sent at any time the circuit is idle without regard to the schedule. The "Q" signal communication will be preceded and followed by one letter shift, one carriage return, and five line feed impulses. "Q" signal communications may be sent by manual operation of the keyboard.

o. Number sheet comparison.—(1) Number sheet comparisons will be made immediately following midnight EST by all stations on schedule "A."

(2) Comparisons will be made in weather sequence order of stations on schedule "A." In cases where stations do not participate in weather sequence collection, their entrance order will be in accordance with circuit data sheets issued by Civil Aeronautics Administration regional office.

(3) The station first scheduled to appear in the sequence will transmit—

(*a*) One letters shift, one carriage return, and five line feed impulses.

(*b*) Identification of transmitting station and one space.

(*c*) A succession of groups, each followed by one space, on which comparison data for each station with which numbered traffic has been exchanged will be indicated as follows (do not exceed 76 characters per line).

1. Identification of station to which comparison data are addressed.

2. Numeral indicating number of messages sent.

3. Slant (/) line.

4. Numeral indicating number of messages received.

After all stations with which numbered traffic has been exchanged have been listed, the sending station will transmit one letters shift, one carriage return, and one line feed impulse.

(4) Each succeeding station, in its proper order, will transmit—

(*a*) Own station identification and space.

(*b*) Groups listing identifications and comparison data for each station with which numbered traffic has been exchanged and from which comparison data have not already been transmitted.

(*c*) One letters shift, one carriage return, and one line feed impulse.

(5) Each station scheduled to appear in the sequence will transmit, if no traffic has been handled, or if stations with which numbered traffic has been exchanged have already transmitted comparison data—

(*a*) Own station identification.

(*b*) One letters shift, one carriage return, and one line feed impulse.

(6) The last station scheduled to enter comparison sequence will conclude the sequence by transmitting one letters shift, one carriage return, and five line feed impulses.

(7) In order to facilitate exchange of comparison data covering any ALL STN, ALL CAA, ALL CKT, and ALL SXN traffic, the station from which the messages were transmitted on any circuit will list these in its number comparison sequence as a separate group (preferably the first) without other identifications, and they will in no case be listed in the received column in the comparison transmissions.

(8) In the case of ALL STN and ALL CAA traffic, a numeral indicating the region concerned must be included, and one dash will be utilized to separate the region number from the number of messages sent. The inclusion of numerals to indicate the region is required, inasmuch as such traffic is occasionally relayed from one region to another for further relay to stations in the region to which the message is addressed.

(9) When stations may transmit direct to each other on two or more circuits, number comparison transmissions will be made on the circuit carrying the lower circuit numerical designator.

(10) Each station will promptly and carefully review the complete sequence and check for accuracy. No confirmation is necessary if the numbers are correct. In the event a discrepancy is noted, the missing number or numbers will be called to the attention of the station concerned, utilizing "Q" signal abbreviations. If the missing traffic is

not immediately located, a duplicate (DUPE) will be transmitted as early as practicable. As soon as the complete sequence has been reviewed, each station will record on Form No. 406 (Daily Communication Report) "Number comparison correct," or "Number comparison incorrect," as the case may be, together with the time of completion of the review, and will then file the received copy of the complete number comparison transmission with traffic for the day concerned.

(11) Example of number comparison data as they would appear on a page teletypewriter:

```
 (5 line feeds)
SA  ALL  CKT2/0  ALLSASMSXN1/0  SM  3/8  KC  3/0  MX  9/13
SM  ALL  STN7-1/0   EF2/2   MX  7/8   DRO/1   BT1/0
KO   MX12/13   DR1/1   BT4/4
MX
DR   BT1/2
BT
 (5 line feed impulses at conclusion of sequence)
```

p. Bell signals.—(1) The following bell signals are authorized for use:

No.
1 End of transmission.
2 Alert signal for any or all U. S. airway communication stations.
3 Alert signal for any or all U. S. Weather Bureau stations.
4 Alert signal for any or all U. S. military stations.
5 Alert signal for all stations.
3-3-3 Precedes transmission of S S S traffic, emergency warning, and accident notice.

(2) The 1-bell signal indicating end of transmission will not be used when scheduled sequence collections are being entered. This will include Hourly Weather sequences, hourly SPL sequences, 6-hourly CS sequences, PIBAL, number comparison sequence, etc.

(3) The 2-, 3-, or 4-bell signals will not be used preceding a transmission, but should only be used following a transmission.

q. Time signals.—(1) The national communication schedule provides for clock synchronizing periods twice daily. In order to insure all stations having the correct time, one station on each circuit will be designated by the regional manager to transmit time as follows, twice each day.

(2) Promptly at 10 seconds before 1000E and 2200E each day, the designated station will transmit five bells and type out the words STAND BY TIME. The station will ring one bell exactly on the hour and all stations will set clocks accordingly. This signal has precedence over all traffic excepting S S S communications.

r. Duplication of dispatches.—(1) If a dispatch is duplicated for any reason, the word DUPE will be transmitted immediately preceding the name of the station where the dispatch originated. A dispatch duplicated on the same day will carry its original serial number. Dispatches duplicated later will carry a new serial number and in all other respects be transmitted as though just originated. A regular dispatch when duplicated will always retain the original date-time group.

(2) Service dispatches when duplicated will transmit the DUPE preceding SUC in the preamble.

s. Voluntary connection and disconnection of teletype equipment.—(1) The voluntary withdrawal of teletypewriters from long line circuits leaving the circuit unguarded is not authorized except at stations having only one printer. Such stations may remove their teletypewriters for routine and emergency servicing, but for no other cause.

(2) The signal QYDA will be transmitted prior to a voluntary interruption of teletypewriter service, in accordance with the following example:

AC QYDA 1215C

The transmission will be preceded and followed by one letters shift, one carriage return, and five line feed impulses.

(3) The signal QYDB will be transmitted when a teletypewriter is reconnected to the circuit following a voluntary interruption.

AC QYDB 1230C

The transmission will be preceded and followed by one letters shift, one carriage return, and five line feed impulses.

t. Communication interruptions (involuntary).—(1) *For teletype stations on one circuit only.*—(*a*) When teletype communication aids fail and the duration of the failure cannot be determined except that it has been current for 20 minutes, the nearest CAA station located on the same circuit should be notified by telephone (station to station rates), or by telegraph if long distance telephone service is not obtainable. In the event of teletype line failure, and when the test room reports that a considerable portion of the circuit is inoperative, stations on only one circuit should not make the report provided for above. However, should the failure be confined to the local loop, the nearest CAA station where teletype facilities are available, as determined from inquiry of the test room, should be notified.

(*b*) The station which received a report of this nature will transmit

a failure notification on the teletype circuit consisting of the words ALL CKT, the number of the teletype circuit, the phrase contraction(s) describing the failure, the teletype identification of the station where the failure occurred, the time the failure occurred and the teletype identification of the transmitting station. The transmission will be preceded and followed by one letters shift, one carriage return, and five line feed impulses. Example:

ALL CKT 9 TYPNO AP 1420C BZ

(*c*) The notification of service resumption will be transmitted by the station where the failure occurred and will consist of the words ALL CKT, the number of the teletype circuit, the phrase contraction(s) describing the resumption of service, the time service was resumed, and the identification of the station. The transmission will be preceded and followed by one letters shift, one carriage return, and five line feed impulses. Example:

ALL CKT 9 TYPOK 1528C AP

(*d*) In the event that the transmission of weather reports by teletype is not practicable due to the failure of these facilities, the next hourly report following the break-down will be telegraphed using the check WEA, or telephoned, collect, to another station on the airway which will be designated by the general supervising official to receive it, and thereafter at 25 minutes past the hours of 1:00 and 7:00 AM and PM, EST, so long as the failure continues.

(2) *For stations on more than one circuit.*—(*a*) When a failure occurs at a circuit junction station, but one or more channels or circuits remain in service, it will usually be possible for the station to advise another station on the circuit or circuits upon which the equipment is inoperative of the failure by service dispatch through relays. This station should thereupon transmit the circuit failure notification in accordance with (1)(*b*) above.

(*b*) Should all communication facilities become inoperative (as in the case of power failure), the nearest station on each circuit should be notified by telephone (station to station rates) and each should transmit a failure notification (see (1)(*b*) above).

(*c*) For transmission of notification of service resumption, see (1)(*c*) above.

(3) *Reporting of interruption of teletype communication service where failure of radio aids to air navigation is involved.*—(*a*) This type of failure is generally attributable to power failure. Where an auxiliary

source of power is not available and it is apparent that power will not become available or service restored within 20 minutes, the nearest station located on the same circuit will be notified by telephone (station to station rates), or by telegraph if long distance telephone is not obtainable. That station will immediately make up and transmit the Flash Notices applicable, and notification of failure of communication aids applicable, to be followed as soon as practicable with a DISPATCH NOTAM addressed to those points on the respective circuits which normally receive DISPATCH NOTAMS from the station where failure occurred.

(*b*) If the failure occurs at a station located on more than one schedule "A" net circuit, the nearest CAA station on each circuit should be notified and each station notified should send the messages listed under (*a*) above.

u. Distribution of radiosonde observations (*APOB*, *RAOB*) *reports.*—(1) *When transmitted.*—Collection of the APOB and RAOB reports into sequences for group relays will be accomplished simultaneously on all originating circuits on schedule "C" during the period 0300–0324, 1500–1524E, daily. Twenty-four minutes are, therefore, provided for the collection of the reports.

(2) *Transmission procedure.*—(*a*) When an APOB–RAOB report normally received at any point for transmission is not filed for transmission in the sequence collections, one of the appropriate phrase contractions, RAWE, RARF, RADI, RARA, RABT, RABA, RAXX, RAHE, RAIF, RALO, RADL, RAFI, APWE, APLO, APBL, APFI, APAF, APPL, APPI, APFD, will be entered in the sequence in place of the report.

(*b*) During the collection each station will transmit one letters shift, one carriage return, and five line feed impulses, followed by its report, and then will transmit one letters shift, one carriage return, and one line feed impulse.

(*c*) Group relay stations will terminate their group transmission with one letters shift, one carriage return, and five line feed impulses.

(*d*) Late reports and corrections, if necessary, will be transmitted at the end of the sequences, except that all transmissions will be terminated at the close of the 24th minute during the hours of 03 and 15, in order to clear the circuits for the APOB–RAOB report sequence relays.

(*e*) Transmission of the last report will be accomplished in the same manner as all other reports in the sequence.

v. Distribution of pilot balloon (*PIBAL*) *reports.*—(1) *When transmitted.*—Collection of the pilot balloon reports on each teletype circuit

of schedule "C" will be accomplished simultaneously beginning a 0005–0605—1205—1805E. The collection of the pilot balloon report on each teletype circuit will be completed as soon as practicable bu will be terminated not later than the beginning of the 15th minut past the hours of 00, 06, 12, 18E. Ten minutes are, therefore, pro vided for the teletype sequence collection of pilot balloon (PIBAL reports.

(2) *Transmission procedure.*—(*a*) The station first listed wil start the sequence collection by the transmission of one letters shift one carriage return, and five line feed impulses followed by its repor and will transmit one letters shift, one carriage return, and one lin feed impulse following the report.

(*b*) Succeeding stations will type their report followed by one letters shift, one carriage return, and one line feed impulse.

(*c*) Late reports and corrections, if necessary, will be transmitted at the end of the sequences, except that all transmissions will be terminated at the close of the 14th minute during the hours of 00, 06, 12, 18E.

(*d*) When a pilot balloon report normally received at any point for transmission is not available for transmission in the sequence collection, one of the appropriate phrase contractions, PIBA, PICO, PIDU, PIFI, PIFO, PIHE, PIIO, PIKO, PIRA, PISE, PISO, PIWI, will be entered in the sequence in place of the report.

w. Coded sequence weather reports (*MT*).—(1) *When transmitted.*—MT reports from all stations designated by the U. S. Weather Bureau to make such reports will be collected in simultaneous sequences on each circuit of origin of schedule "C" during the periods 0130–0135, 0730–0735, 1330–1335, 1930–1935E, inclusive.

(2) *Transmission procedure.*—(*a*) The station first listed will start the sequence collection by the transmission of one letters shift, one carriage return, and five line feed impulses, followed by its report, and will transmit one letters shift, one carriage return, and one line feed impulse following the report.

(*b*) Succeeding stations will type report followed by one letters shift, one carriage return, and one line feed impulse.

(3) *Relays.*—The relay of MT reports will be accomplished on all circuits during the periods 0135–0159, 0735–0759, 1335–1359, and 1935–1959E, inclusive.

x. Distribution of 6-hourly weather map (*M*) *reports.*—(1) All M transmissions and relays will be accomplished during the periods allotted in the national communication system, schedule "C."

(2) M reports originating at off-airway points will be handled in

groups which will originate for teletype transmission purposes as follows:

Group	
MP—Primary	Denver.
ME—Eastern Canada	Toronto.
MW—Western Canada	Vancouver.
MS—Supplementary	Denver.
MH—Atlantic ships	Washington.
MJ—Pacific ships	Oakland.
MK—Mexican	San Diego.
ML—Western Pacific and Asiatic	Oakland.
MM—Miscellaneous	Washington.

(3) *When transmitted.*—Transmissions and relays of MP reports will follow immediately upon the completion of the sequence relays of MT reports, but starting not later than the periods 0200, 0800, 1400, and 2000E. The MP reports will be followed in turn by the ME, MW, MS, MH, MJ, MK, ML, and MM reports.

y. Distribution of 3-hourly (3M) reports.—(1) Three-hourly (3M) reports will be transmitted during the 3M periods allotted in the national communication system, schedule "C."

(2) Three-hourly (3M) reports are received from sources, some of which are not on the teletype circuits, and will be assembled by the U. S. Weather Bureau for teletype transmission.

z. Distribution of airway and terminal forecasts (FA).—Airway and terminal forecasts originate at New York, N. Y.; Washington, D. C.; Atlanta, Ga.; New Orleans, La.; Cleveland, Ohio; Chicago, Ill.; Kansas City, Mo.; Fort Worth, Tex.; Salt Lake City, Utah; Seattle, Wash.; Oakland, Calif.; Albuquerque, N. Mex.; and Burbank, Calif. They are transmitted from these points on schedule "C."

aa. Distribution of state forecasts (FS).—The state forecasts originate at Boston, Mass.; Washington, D. C.; Jacksonville, Fla.; New Orleans, La.; Chicago, Ill.; Kansas City, Mo.; Albuquerque, N. Mex.; Denver, Colo.; Salt Lake City, Utah; Los Angeles, Calif.; and San Francisco, Calif. They are transmitted from these points on schedule "C."

ab. Air mass and frontal analysis reports (AMAFA).—These reports originate only in Washington, D. C., at present, and are transmitted from that point on schedule "C" in the form outlined in Weather Bureau Circular N, and any revisions thereto.

ac. Crop region, river, corn and wheat, fruit service, and horticultural reports (CR).—(1) Collection and distribution of CR reports will be accomplished during the daily period allotted therefor in the national communication system, schedule "C."

(2) CR reports from all stations designated by the Weather Bureau to make such reports will be collected in simultaneous sequences on each circuit of origin during the periods allotted in the national communication system, schedule "C."

(3) The station first listed will start the sequence collection by the transmission of one letters shift, one carriage return, two line feed impulses, station identification, sequence designator (CR), time and zone designator. Example: PW CR 1000E, followed by the report, which will be followed by one letters shift, one carriage return, and two line feed impulses.

(4) Succeeding stations will type report, followed by one letters shift, one carriage return, and two line feed impulses.

ad. Forecasts bulletins (FB).—See *ac* above, with the exception that the sequence designator FB will be used in place of the sequence designator CR.

ae. Lake and marine forecasts (FL).—See *ac* above, with the exception that the sequence designator FL will be used in place of the sequence designator CR.

af. Special map reports (SM).—See *ac* above, with the exception that the sequence designator SM will be used in place of the sequence designator CR.

ag. Provisional forecasts, special warning and advisories (FP).—See *ac* above, with the exception that the sequence designator FP will be used in place of the sequence designator CR.

ah. Map analysis and weather summaries (MA).—See *ac* above, with the following two exceptions:

(1) Use sequence designator MA in place of sequence designator CR.

(2) When no MA report is on hand for transmission, the following procedure will be used: Transmit station identification, one space, sequence designator MA, time and zone designator, the phrase FINO, followed by one letters shift, one carriage return, and two line feed impulses. Example: KC MA 0550E FINO.

99. Abbreviations and phrase contractions.

Days of the week

Sunday	SUN	Thursday	THU
Monday	MON	Friday	FRI
Tuesday	TUE	Saturday	SAT
Wednesday	WED		

Months of the year

January	JAN	July	JUL
February	FEB	August	AUG
March	MAR	September	SEP
April	APR	October	OCT
May	MAY	November	NOV
June	JUN	December	DEC

Cloud formations

altocumulus	AC	fractocumulus	FC
altocumulus castellatus	ACC	fractostratus	FS
altostratus	AS	mammatocumulus (cumulonimbus mammatus)	CM
cirrocumulus	CC	nimbostratus	NS
cirrostratus	CS	stratocumulus	SC
cirrus	CI	stratus	ST
cumulonimbus	CB		
cumulus	CU		

States

Alabama	ALA	Nebraska	NEB
Arizona	ARIZ	Nevada	NEV
Arkansas	ARK	New Hampshire	NH
California	CALIF	New Jersey	NJ
Colorado	COLO	New Mexico	NM
Connecticut	CONN	New York	NY
Delaware	DEL	North Carolina	NC
District of Columbia	DC	North Dakota	ND
Florida	FLA	Ohio	OHIO
Georgia	GA	Oklahoma	OKLA
Idaho	IDA	Oregon	OREG
Illinois	ILL	Pennsylvania	PA
Indiana	IND	Rhode Island	RI
Iowa	IA	South Carolina	SC
Kansas	KAN	South Dakota	SD
Kentucky	KY	Tennessee	TENN
Louisiana	LA	Texas	TEX
Maine	ME	Utah	UTAH
Maryland	MD	Vermont	VT
Massachusetts	MASS	Virginia	VA
Michigan	MICH	Washington	WASH
Minnesota	MINN	West Virginia	WVA
Mississippi	MISS	Wisconsin	WIS
Missouri	MO	Wyoming	WYO
Montana	MONT		

Proper names

Adirondack	ADRNDCK	Hawaii	HWI
Alaska	ALSK	Keewatin	KWTN
Alberta	ALTA	Labrador	LBRDR
Aleutian	ALUTN	Mackenzie	MCKNZ
Allegheny	ALGHNY	Manitoba	MANT
Appalachian	APLCHN	Mexican	MEXN
Atlantic	ATLC	Mexico	MEX
Berkshire	BRKSHR	New Brunswick	NB
Bermuda	BDA	Newfoundland	NF
Blackhills	BLKHLS	New England	NWENG
British Columbia	BC	Nova Scotia	NS
Continental Divide	CONTDVD	Ontario	ONT
Canada	CAN	Pacific	PAC
Canadian	CNDN	Panhandle	PNHDL
Catskills	CTSKLS	Puget Sound	PGTSND
Cascades	CASCDS	Quebec	QUE
Chesapeake	CHSPK	Rocky (ies)	RCKY
Dakotas	DKTS	Sierra Nevada	SIERNEV
Grand Banks	GRBNKS	Siskiyou	SISKY
Great Lakes	GRTLKS	Saskatchewan	SASK
Great Plains	GRTPLNS	United States	US
Gulf of Mexico	GLFMEX	Western Plateau	WPLTO
Gulf of St. Lawrence	GLFSTLAWR	Yukon	YKN

Military aircraft types

bomber landplane	BLP	patrol seaplane	PSP
bomber seaplane	BSP	scout landplane	SLP
fighter landplane	FLP	scout seaplane	SSP
fighter seaplane	FSP	seaplane	SP
landplane	LP	transport landplane	TLP
observation landplane	OLP	transport seaplane	TSP
observation seaplane	OSP	utility landplane	ULP
patrol landplane	PLP	utility seaplane	USP

Civil aircraft types

Aeronca	ARCA	Lockheed	LKHD
Beechcraft	BCFT	Luscombe	LSCB
Bellanca	BLCA	Sikorsky	SKSY
Boeing	BOIG	Stearman	STMN
Douglas	DGLS	Stinson	STSN
Electra	ELKA	Vega	VEGA
Fairchild	FCLD	Waco	WACO
Grumman	GRMN		

Air mass names

polar Atlantic	POLAT
polar continental	POLCO
polar Pacific	POLPA
superior	SUPR
transitional polar	TSLPOL
transitional polar Atlantic	TSLPOLAT
transitional polar continental	TSLPOLCO
transitional polar pacific	TSLPOLPA
transitional tropical Atlantic	TSLTRPAT
transitional tropical Gulf	TSLTRPGU
transitional tropical maritime	TSLTRPMA
transitional tropical Pacific	TSLTRPPA
tropical Atlantic	TRPAT
tropical Gulf	TRPGU
tropical maritime	TRPMA
tropical Pacific	TRPPA

Railroads

Alaska Railroad	ARR
Alaska Steamship Company	ASCO
Atchison, Topeka & Santa Fe	ATS
Atlanta, Birmingham & Coast	ABC
Atlantic Coast Line	ACL
Baltimore & Ohio	BAO
Bangor & Aroostock	BAA
Bessemer & Lake Erie	BLE
Boston & Maine	BAM
Buffalo, Rochester & Pittsburgh	BRP
Central of Georgia	COG
Central RR of New Jersey	CNJ
Central Vermont	COV
Chesapeake & Ohio	CAO
Chicago & Alton	CGA
Chicago, Burlington & Quincy	CBQ
Chicago & Eastern Illinois	CEI
Chicago Great Western	CGW
Chicago, Indianapolis & Louisville	CIL
Chicago, Milwaukee, St. Paul & Pacific	CMS
Chicago & North Western	CNW
Chicago, Rock Island & Gulf	CRI
Chicago, Rock Island & Pacific	CRP
Chicago, St. Paul, Minneapolis & Omaha	CSO
Cincinnati, New Orleans & Texas Pacific	CNP
Colorado & Southern	CAS
Delaware & Hudson	DAH
Delaware, Lackawanna & Western	DLW
Denver & Rio Grande Western	DRG
Detroit, Toledo & Ironton	DTI
Duluth, Missabe & Northern	DMN
Duluth, South Shore & Atlantic	DSA
Elgin, Joliet & Eastern	EJE
Erie RR	ERR
Florida East Coast	FEC
Fort Smith & Western	FSW
Fort Worth & Denver City	FAD
Georgia RR	GRR
Grand Trunk Western	GTW
Great Northern	GRN
Greyhound Bus	GYB
Illinois Central	ILC
International-Great Northern	IGN
Kansas City Southern	KSO
Kansas, Oklahoma & Gulf	KOG
Lake Erie Franklin-Clarion	LFC
Lehigh Valley	LVA
Long Island	LOI
Los Angeles & Salt Lake	LAS
Louisville & Nashville	LAN
Maine Central	MCE
Midland Valley	MVA
Minneapolis & St. Louis	MSS
Minneapolis, St. Paul & Sault Ste. Marie	MPM
Missouri-Kansas-Texas of Texas	MTT

Railroads—Continued

Mobile & Ohio	MAO
Nashville, Chattanooga & St. Louis	NCL
New York Central	NYC
New York, Chicago & St. Louis	NCS
New York, New Haven & Hartford	NNH
New York, Ontario & Western	NOW
Norfolk Southern	NSO
Norfolk & Western	NAW
Northern Pacific	NOP
Oklahoma City, Ada & Atoka	OAA
Oregon Short Line	OSL
Oregon-Washington RR & Nav. Co	OWC
Pennsylvania	PRR
Pere Marquette	PMQ
Pittsburgh & Lake Erie	PLE
Quincy, Omaha & Kansas City	QOK
Reading Co	RCO
Richmond, Fredericksburg & Potomac	RFP
Rock Island Southern	RIS
Rutland	RUT
Santa Ana Steamship Co	SACO
St. Louis, Brownsville & Mexico	SBM
St. Louis-San Francisco	SSF
St. Louis Southwestern	SLS
St. Louis Southwestern of Texas	SST
Seaboard Air Line	SAL
Southern Pacific	SOP
Southern Railway	SRR
Spokane, Portland & Seattle	SPS
Texas & Pacific	TXP
Texas & New Orleans	TXN
Union Pacific	UNP
Union Traction	UNT
Virginian	VRR
Wabash	WRR
Western Maryland	WEM
Western Pacific	WEP
Wheeling & Lake Erie	WLE

Air carrier operators

American Export Airlines	AEA
Airlines Charter Service	ACS
Airline Feeder System	AFS
All American Aviation Incorporated	AAA
American Airlines	AAL
Braniff Airways	BNF
Canadian Airways	CNA
Canadian Colonial Airways	CCA
Central Vermont Airways	CVA
Chicago & Southern Air Lines	CHI
Continental Air Lines	CAL
Delta Air Lines	DAL
Eastern Air Lines	EAL
Inland Air Lines	INL
Marquette Airlines	MAL
Mid-Continent Airlines	MCA
National Airlines	NAL
Northeast Airlines	NEA
Northwest Airlines	NWA
Pacific Alaska Airways	PAA
Pan American Airways	PAA
Pennsylvania Central Airlines	PCA
Star Air Lines	STR
Trans Canada Air Lines	TCA
Transcontinental & Western Air	TWA
United Air Lines	UAL
Western Air Lines	WAL
Woodley Airways	WAA

Wind directions and variations

	Code
North (ern) (erly) (ward)	N, NRN, NLY, NWD
North northeast (ern) (erly) (ward)	NNE, NNERN, NNELY, NNEWD
Northeast (ern) (erly) (ward)	NE, NERN, NELY, NEWD
East northeast (ern) (erly) (ward)	ENE, ENERN, ENELY, ENEWD

Wind directions and variations—Continued

	Code
East (ern) (erly) (ward)	E, ERN, ELY, EWD
East southeast (ern) (erly) (ward)	ESE, ESERN, ESELY, ESEWD
Southeast (ern) (erly) (ward)	SE, SERN, SELY, SEWD
South southeast (ern) (erly) (ward)	SSE, SSERN, SSELY, SSEWD
South (ern) (erly) (ward)	S, SRN, SLY, SWD
South southwest (ern) (erly) (ward)	SSW, SSWRN, SSWLY, SSWWD
Southwest (ern) (erly) (ward)	SW, SWRN, SWLY, SWWD
West southwest (ern) (erly) (ward)	WSW, WSWRN, WSWLY, WSWWD
West (ern) (erly) (ward)	W, WRN, WLY, WWD
West northwest (ern) (erly) (ward)	WNW, WNWRN, WNWLY, WNWWD
Northwest (ern) (erly) (ward)	NW, NWRN, NWLY, NWWD
North northwest (ern) (erly) (ward)	NNW, NNWRN, NNWLY NNWWD

Word endings—Variations of root words may be formed as follows

able	BL
al	L
ally, erly, ly	LY
ary, ery, ory	RY
(add Y if word ends in L)	
ance, ence	NC
der	DR
ance, ence	NC
der	DR
ed, ied	D
(add ED if word ends in D)	
ening	NG
er, ier, or	R
ern	RN
ically	CLY
iest	ST
iness, ness	NS
ing	G
(add NG if word ends in G)	
ity	TY
ive	V
ment	MT
ous	US
s, es, ies	S
tion, ation	N
ward	WD

Words and phrase contractions

abnormal	ABNML
aboard	ABRD
about	ABT
above	ABV
absorb	ABSB
abundance	ABNDC
accelerate	ACELT
accept	ACPT
accompany	ACPY
accord	ACRD
account	ACCT
acknowledge	ACK
across	ACRS
accumulate	ACMLT
acting	ACTG
action	ACTN
active	ACTV
addition	ADN
address	ADS
adequate	ADQT
Adirondack	ADRNDCK
adjacent	ADJT
adjoin	ADJN
advance	ADVN
adverse	ADVR
advice	ADVC
advise	ADVZ
advisory	ADVZY
aerological	AERLGL
aerology	AERLY
aeronautical	AERNL
affect	AFCT

Words and phrase contractions—Continued

affirm	AFM	apparent	APRT
after	AFT	appear	APPR
afternoon	AFTN	appoint	APNT
again	AGN	approach	APCH
aggress	AGRS	approve	APV
ahead	AHD	approximate	APRX
aircraft	ACFT	arbitrary	ARBTY
airmass	AMS	around	ARND
airport	ARPT	arrange	ARNG
airway	AWY	arrive	ARV
Alaska	ALSK	ascend	ASCD
Alberta	ALTA	ascent	ASCT
Aleutian	ALUTN	assign	ASGN
Allegheny	ALGHNY	associate	ASOCT
aloft	ALF	assume	ASM
along	ALG	assumption	ASMN
alternate	ALTN	Atlantic	ATLC
altitude	ALT	atmosphere	ATSPH
amalgamate	AMGT	attach	ATCH
amount	AMT	attempt	ATMT
analogous	ANLGS	attend	ATND
analysis	ANLYS	Aurora Borealis	AURBO
analyze	ANLZ	authorize	AUZ
another	ANTHR	automatic	AUTO
answer	ANS	auxiliary	AUX
antenna	ANT	avail	AVL
anticipate	ANCPT	avenue	AVE
Appalachian	APLCHN	average	AVG

account weather	AWEA
advise effective date	ADEDA
advise or issue instructions to all concerned	ADCON
advise this office	ADVOF
air mail operations	AMO
Air Navigation Radio Aids	ANRA
airplane observation delayed, to be transmitted later	APDL
airplane observation not filed	APFI
Airport control tower	APT
Airport control tower radio facilities not operating until further notice	APTNO
Airport control tower radio facilities resumed operation	APTOK
Airway tariffic control	ATC
Airways weather office	AWO
air mass and frontal analysis	AMAFA
airplane weather observations	APOBS
Alaskan standard (time)[1]	A
all principal communications operators	ALLPO

[1] When used immediately at end of a four-figure time group.

Words and phrase contractions—Continued

all senior communications operators	ALLSO
all communications operators	ALLCO
all assistant communications operators	ALLAO
all junior communications operators	ALLJO
all under communications operators	ALLUO
all relief under communications operators	ALLRU
all emergency relief communications operators	ALLER
alternate field	ALTF
alternate flight plan	AFP
altimeter setting	ALSTG
American Telephone and Telegraph Company	ATT
ante meridian	AM
as soon as practicable	ASSAP
attention signal not operating	ATNNO
attention signal resumed operation	ATNOK
approval requested	APREQ
authority granted	AUGRA
authority is requested	AUZRE
Army radio	ARDO

back	BCK
baggage	BAG
balance	BLC
ballast	BLST
barometer	BRM
barometric	BRMC
beacon	BCN
become	BCM
before	BFR
begin	BGN
below	BLO
beneath	BNTH
Berkshire	BRKSHR
better	BTR
between	BTWN
beyond	BYD
black	BLK
Blackhills	BLKHLS
blanket	BLKT
blow	BLW
blowing dust [2]	BD
blowing sand [2]	BN
blowing snow [2]	BS
border	BDR
bound	BND
boundary	BNDRY
break	BRK
bright	BRGT
British Columbia	BC
broadcast	BDC
broken	BRKN
build	BLD

beacon light burning but not revolving until further notice	BEBNR
beacon light not burning until further notice	BENBU
beacon resumed normal operation	BEBOK
Bearing standard (time)[1]	B
bill(s) of lading	BL
breaks in overcast	BINOVC
Broadcast not operating until further notice	BRONO
Broadcast resumed operation	BROOK
broken clouds to overcast	BCTOVC
Bureau letter	BULET

[1] When used immediately at end of a four-figure time group.
[2] To be used in weather reports only.

Words and phrase contractions—Continued

calm [3]	C	communicate	CMCT
Canada	CAN	company	CO
Canadian	CNDN	compartment	CMPT
cancel	CNCL	commandant	COMDT
capacity	CPTY	commander	COMDR
captain	CAPT	compass	CMPS
Catskills	CTSKLS	complete	COMP
Cascades	CASCDS	compose	CPZ
caution	CTN	condense	CDNS
ceiling	CIG	condition	CND
center	CNTR	confine	CFN
central	CNTRL	confirm	CFM
change	CHG	connect	CNT
character	CARCTR	consider	CSDR
characteristic	CARCTRC	construct	CONST
charter	CHTR	contact	CTC
check	CK	contact [1]	C
Chesapeake	CHSPK	Continental Divide	CONTDVD
circle	CRC	continue	CONT
circuit	CKT	control	CTL
circular	CIR	convection	CNVCTN
clear	CLR	convective	CNVCTV
climb	CLB	converge	CNVRG
clockwise	CLKWZ	correct	CQT
close	CLZ	correction	CQN
closed [4]	X	counterclockwise	CNTRCLKWZ
cloud	CLD	course	CRS
coast	CST	cover	CVR
colonel	COL	cross	CROS
commerce	CMRC	cruise	CRZ
commence	CMNC	crystal	XTL
commission	CMSN	cylinder	CYL

caution advised until further notice	CAUFN
ceiling and visibility unlimited	CAVU
ceiling unrestricted	CIGUN
Central standard (time) [4]	C
Civil Aeronautics Administration	CAA
Commanding Officer	CO
clear to scattered clouds	CTSCLDS
close this office	CLOTO
Coast Guard	CSTGRD
Coast Guard radio	CGRDO
confirming requisition follows	COREQ
contact flight rule	CFR

[1] When used immediately preceding a four-figure time group.
[3] When used in wind velocity position of symbol weather report.
[4] Used in symbol weather reports following station identification to indicate weather classification.

Words and phrase contractions—Continued

Dakotas	DKTS	deviate	DVT
damp haze [2]	F—	dew point	DWPNT
danger	DGR	diagonal	DGNL
dark	DRK	diminish	DMSH
daybreak	DABRK	direct	DRCT
daylight	DALGT	discontinue	DSCONT
decline	DCLN	dispatch	DIS
decrease	DCRS	displace	DSPLC
deepen	DPEN	disposition	DSPN
define	DFN	disregard	DSRGRD
definite	DFNT	dissipate	DSIPT
degree	DGRE	distance	DSTC
delay	DLA	distant	DSNT
deliver	DLVR	distribute	DRBT
demonstrate	DMNST	district	DIST
dense	DNS	disturb	DSTB
depart	DPT	diverge	DVRG
departed [1]	D	division	DVN
departure	DPTR	dominant	DMNT
depend	DPND	double	DBL
deplane	DPLN	doubt	DBT
depress	DPRS	doubtful	DBTF
depth	DPTH	downward	DWNWD
descend	DSND	drift	DRFT
designate	DSGNT	drifting snow [2]	GS
desire	DSR	drizzle	DRZL
destination	DSTN	drizzle [2]	L
detain	DTN	drop	DRP
detect	DTCT	duplicate	DUPE
determine	DTRM	duration	DURN
detrain	DTRN	during	DURG
develop	DVLP	dust [2]	D

day frequency	DFQ
deadhead	DHD
delayed weather	DW
Department of Commerce	DOC
dispatch reply	DIREP
disregard former service	DFS

eastbound	EABND	encounter	ENCTR
effect	EFCT	endure	ENDR
electric	ELTC	engine	ENGN
elevate	ELV	enroute	ENRT
eliminate	ELMT	entire	ENTR
elongate	ELNGT	envelope	ENVP
elsewhere	ELSW	equalize	EQLZ
emergency	EMGCY	equip	EQP

[1] When used immediately preceding a four-figure time group.
[2] To be used in weather reports only.

Words and phrase contractions—Continued

essential	ESNTL
establish	ESTBL
estimated	ETD
estimated [5]	E
etcetera	ETC
evaporate	EVPT
evening	EVE
exact	XAC
examine	XAM
excellent	XLNT
except	XCP
exchange	XCHG
exist	XST
expect	XPC
expedite	XPDT
express	XPS
extend	XTD
extension	XTSN
extensive	XTSV
extreme	XTRM

elapsed time	EPSTM
Eastern Standard (time) [1]	E
entered on duty	EOD
estimated time of arrival	ETA
estimated time of departure	ETP
estimated time en route	ETE
estimated time over	ETOV
expedite mail reply	EXREP
expedite shipment	EXSHI

falling	FLG
factory	FCTY
favor	FVR
federal	FED
feet; fort; foot	FT
field	FLD
flight	FLT
flurry	FLRY
fog [2]	F
follow	FLW
forecast	FCST
forenoon	FORNN
form	FRM
forward	FWD
freeze	FRZ
freezing drizzle [2]	ZL
freezing rain [2]	ZR
frequent	FQT
frequency	FQCY
fresh	FRSH
frost	FRST
frozen	FRZN
further; farther	FTHR

fair and colder	FAIRAC
fair and continued cold	FAIRACC
fair and continued warm	FAIRACW
fair and warmer	FAIRAW
familiarization flight	FFLT
fan type marker found operating normally	FAFON
fan type marker not heard	FANHD
fan type marker not operative until further notice	FANOT
fan type marker resumed operation	FAROK
Federal Airways Service	FAS
feet per minute	FPM
field and lighting facilities	FILLI
field notice to airmen is current	FINAC

[1] When used immediately at end of a four-figure time group.
[2] To be used in weather reports only.
[5] Used immediately preceding a ceiling height or following a wind velocity value in a symbol weather report.

Words and phrase contractions—Continued

flight plan	FPLN
forward confirming requisition	FOCOR
full tanks	FTNX

gallon	GAL	ground	GND
gasoline	GAS	ground fog	GNDFG
general	GNRL	ground fog [2]	GF
generate	GNRT	group	GRP
government	GOVT	guard	GRD
gradual	GRDL	gulf	GLF
Grand Banks	GRBNKS	Gulf of Mexico	GLFMEX
great	GRT	Gulf of St. Lawrence	GLFSTLAWR
Great Lakes	GRTLKS	gust	GST
Great Plains	GRTPLNS		

general headquarters	GHQ
get quick answer	GQA
give better address	GBA
Greenwich civil (time) [1]	G

hail [2]	A	high	HI
half	HLF	highway	HIWA
hang	HNG	hold	HLD
Hawaii	HWI	horizon	HRZN
hazy	HZY	hour	HR
hazy [2]	H	humid	HMD
head	HD	hundred	HND
headquarters	HDQTRS	hurricane	HURCN
headwind	HDWND	hydrographic	HYDRO
heavy	HVY		

Hawaiian standard (time) [1]	H
hourly sequence weather report not filed	FINO

ice fog [2]	IF	incorrect	INCQT
icing	ICG	increase	INCR
identification	IDNFCN	indefinite	INDFNT
identify	IDNFY	indicate	INDC
immediate	IMDT	information	IFN
importance	IMPTC	initial	INTL
important	IMPT	inspect	INSP
improve	IPV	install	INSTL
inadequate	INADQT	instruct	INST
include	INCL	instrument	INSTMT
inclusive	INCLV	instrument [4]	N
incomplete	INCOMP	intense	INTS
incorporate	INC	interior	INTR

[1] When used immediately at end of a four-figure time group.
[2] To be used in weather reports only.
[4] Used in symbol weather reports following station identification to indicate weather classification.

Words and phrase contractions—Continued

intermediate	INTMD	interval	ITVL
intermittent	INTMT	irregular	IREG
interrupt	INTRP	island	ISL
intersect	INTSX	investigate	INVSGT

icing in clouds	ICGIC
icing in precipitation	ICGIP
in the overcast	IOVC
information requested	INREQ
instrument flight rule	IFR
junction	JCTN

Keewatin	KWTN	level	LVL
kilocycle	KC	lift	LFT
kilowatt	KW	Lieutenant	LT
Kollsman	KOL	light	LGT
laboratory	LAB	lighting	LTNG
Labrador	LBRDR	likely	LKLY
land	LND	limit	LMT
later	LTR	local	LCL
latitude	LATD	localizer	LCZR
latitudinal	LATDNL	locate	LCT
latter	LTTR	longitude	LNGD
layer	LYR	longitudinal	LNGDNL
leave	LEV	lower	LWR

letter follows	LETFO
Lieutenant Commander	LTCOMDR
little change in temperature	LCTMP

Mackenzie	MCKNZ	middle	MID
mail	ML	midnight	MIDN
maintain	MNTN	mile	MI
maintenance	MNTNC	minimum	MIM
major	MAJ	minute	MIN
manager	MGR	missing	MISG
Manitoba	MANT	missing [6]	M
maritime	MRTM	mistake	MSTK
mark	MRK	Mister	MR
material	MTRL	Mistress	MRS
maximum	MAX	mixed	MXD
mechanic	MCK	moderate	MDT
mechanician	MCKN	moisture	MSTR
message	MSG	morning	MRNG
meteorological	METGL	most	MST
Mexican	MEXN	mountain	MTN
Mexico	MEX	move	MOV

[6] Used in symbol weather reports in place of element ordinarily reported.

Words and phrase contractions—Continued

magnetic heading	MHDG
Manual of Operations	MANOP
mean sea level	MSL
miles per hour	MPH
Mountain Standard (time) [1]	M

necessary	NEC	next	NXT
neighborhood	NBRHD	night	NGT
never	NVR	normal	NRML
nevermind	NVRMD	northbound	NOBND
New Brunswick	NB	Nova Scotia	NS
New England	NWENG	number	NUM
Newfoundland	NF	numerous	NMRS

National Communication System	NACOS
Naval Reserve Air Base	NRAB
Navy radio	NRDO
Navy Yard	NYD
night frequency	NFQ
no airplane observation, aerometeorograph failure	APAF
no airplane observation, field unsafe or closed	APFD
no airplane observation, maximum altitude less than 500 meters above ground	APLO
no airplane observation, no airplane available	APPL
no airplane observation, no pilot available	APPI
no airplane observation, unfavorable weather	APWE
no airplane observation for any reason not given above	APXX
no pilot balloon observation, foggy	PIFO
no pilot balloon observation, instrument trouble	PIIO
no pilot balloon observation, low clouds	PICO
no pilot balloon observation, no balloons	PIBA
no pilot balloon observation, no gas	PIHE
no pilot balloon observation, raining	PIRA
no pilot balloon observation, smoky	PIKO
no pilot balloon observation, snowing	PISO
no pilot balloon observation, thick dust	PIDU
no pilot balloon observation, high or gusty surface wind	PIWI
no pilot balloon observation, unfavorable sea conditions	PISE
no radiosonde observation, instrument disabled in launching	RADI
no radiosonde observation, instrument failure	RAIF
no radiosonde observation, maximum altitude less than 500 meters above ground	RALO
no radiosonde observation, no balloons on hand	RABA
no radiosonde observation, no batteries on hand	RABT
no radiosonde observation, no gas on hand	RAHE
no radiosonde observation, no radiosonde on hand	RARA
no radiosonde observation, recorder failure	RARF
no radiosonde observation, unfavorable weather	RAWE

[1] When used immediately at end of a four-figure time group.

Words and phrase contractions—Continued

no radiosonde observation filed	RAFI
no radiosonde observation for any reason not given above	RAXX
no reply received	NORXP
no radio	NORDO
no space released	NSRL
no space reserved	NSRD
Notice to Airmen	NOTAM
not much change in temperature	NOMUCHTMP
not operative	NOOPV
not quite so cold	NOQSC
not to exceed	NOTOX

obscure	OBSC
observe	OBS
obstruct	OBST
occasion	OCN
occlude	OCLD
occur	OCUR
operate	OPT
Ontario	ONT
operations per minute	OPM
on time	OTI
on top	OTP
order	ORDR
other	OTR
otherwise	OTRW
ounce	OZ
over	OVR
overcast	OVC
overdue	OVD
overhead	OVHD
overnight	OVNGT
overrun	OVRN
overtake	OVTK
Pacific	PAC
Panhandle	PNHDL
paragraph	PARA
parcel	PRCL
partly	PTLY
passenger	PSGR
passing	PSG
patch	PTCH
penetrate	PNTRT
period	PRD
permission	PMSN
permit	PMT
persist	PRST
pickup	PUP
piece	PCS
please	PSE
point	PNT
portion	PTN
position	PSN
possible	PSBL
pouch	PCH
pound	PND
power	PWR
preceed	PECD
precipitation	PCPN
pressure	PRES
prevail	PVL
prevalent	PVLT
principal	PCPL
probable	PBL
proceed	POCD
progress	PGRS
propeller	PROP
protect	PTK
publish	PUBSH
Puget Sound	PGTSND

Pacific Standard (time)[1]	P
Pacific Telephone and Telegraph Company	PTT
Pan-American Airways communications office	PANCOM
Pan-American Airways meteorological office	PANMET
pilot balloon observation not filed	PIFI

[1] When used immediately at end of four-figure time group.

Words and phrase contractions—Continued

pilot balloon sequence reports	PIBAL
pilot reports	PIREPS
plan to clear	PTC
post meridian	PM
post office	PO
power supply failure	POWNO
power supply restored	POWOK
proposed departure [1]	P

quadrant	QUAD
quantity	QNTY
quarter	QTR
Quebec	QUE
quick	QK
quiet; quart	QT
quote	QOT
radio	RDO
ragged	RGD
railroad	RR
rain [2]	R
rain showers [2]	RW
rain squall [2]	RQ
range	RNG
rapid	RPD
reach	RCH
receive	RCV
recommend	RCMD
reference	RE
refuel	RFL
refuse	RFS
regard	RGRD
register	REG
region	RGN
regional office	RO
regular	RGLR
regulate	RGLT
relay	RLA
release	RLS
relief	RLF
relieve	RLV
remain	RMN
remark	RMRK
remind	RMD
remove	RMV
repeat	RPT
replace	RPL
report	RPRT
request	REQ
require	RQR
requisition	RQN
reserve	RSV
reservation	RSVN
retard	RTRD
restrict	RST
return	RTN
returned [1]	R
reveal	REVL
ridge	RDG
right	RGT
risen	RSN
rising	RSG
river	RVR
Rocky (ies)	RCKY
rough	RUF
route	RTE
runway	RNWY

radio and communication	RACOM
radio and communication facilities inoperative until further notice	RACFI
radio and communication facilities operative	RACFO
radio facilities notice to airmen is current	RANAC
radio range appears unreliable	RARAU
radio range not operating until further notice	RANOT
radio range resumed operation	RAGOK

[1] When used immediately preceding a four-figure time group.
[2] To be used in weather reports only.

Words and phrase contractions—Continued

radio receiving facilities not operative until further notice	RCVNO
radio receiving facilities resumed operation	RCVOK
radiosonde observations	RAOBS
radiosonde observation delayed, to be transmitted later	RADL
receiving only	RONLY
reference instruction bulletin	REBUL
recommend approval	RECOK
reference contact	RECON
reference dispatch	REDIS
reference endorsement	REFEN
reference invoice	REINV
reference letter	RELET
reference mailgram	REMAG
reference Notice to Airmen	RENOA
reference proposal	REPRO
reference requisition	REREQ
reference telegram	RETEL
reference this office contract	ROCON
reference dispatch from this office	RODIS
reference endorsement from this office	ROEND
reference invoice from this office	ROINV
reference letter from this office	ROLET
reference mailgram from this office	ROMAG
reference this office Notice to Airmen	RONOA
reference requisition from this office	ROREQ
reference telegram from this office	ROTEL
reference contract from your office	RUCON
reference dispatch from your office	RUDIS
reference endorsement from your office	RUEND
reference invoice from your office	RUINV
reference letter from your office	RULET
reference mailgram from your office	RUMAG
reference Notice to Airmen from your office	RUNOA
reference requisition from your office	RUREQ
reference telegram from your office	RUTEL
reference our telephone conversation	REPHO
remaining overnight	ROVNGT
reply requested	RYRQD
resumed operation	RSOPN

Saskatchewan	SASK
scatter	SCT
schedule	SKJ
search	SRCH
second	SEC
section	SXN
sector	SCTR
separate	SPT
sequence	SEQ
sergeant	SGT
service	SVC
settle	STL
several	SVRL
severe	SVR
shallow	SHLW
shift	SHFT
shower	SHWR
Sierra Nevada	SIERNEV

Words and phrase contractions—Continued

signature	SIG
single	SNGL
Siskiyou	SISKY
situate	SIT
sleet	SLT
sleet [7]	E
slight	SLGT
slow	SLW
small hail [2]	AP
smoke [2]	K
snow	SNW
snow [7]	S
snow pellets	SP
snow showers [7]	SW
snow squall	SQ
sometime	SMTM
somewhat	SMWHT
southbound	SOBND
special	SPL
specification	SPEC
spread	SPRD
sprinkle	SPKL
squadron	SQDN
squall	SQAL
standard	STDRD
state	STA
station	STN
steamship	SS
steward	STWD
stop	STP
storm	STM
stratosphere	STRSPH
street or saint	ST
strong	STG
subside	SBSD
sufficient	SFCT
suggest	SGST
summary	SMRY
sunrise	SUNRS
sunset	SUNST
superintendent	SUPT
superior	SUPR
surface	SFC
surround	SRND
synoptic	SYN
system	SYM

sectional aeronautical chart	SXNAC
see our service	SRS
see your service	SYS
slowly rising temperature	SRTMP
smoke and fog mixed	KAFMXD
subject load	SBLD
submit requisition	SUREQ
station location marker, ultra high frequency found operating normally	ZOFON
station location marker, ultra high frequency not heard	ZONHD
station location marker, ultra high frequency not operating until further notice	ZONOT
station location marker, ultra high frequency resumed operation	ZOHOK

take off	TKOF
telephone	TLFO
teletype	TLTP
temperature	TMP
tend	TND
tendency	TNDCY
tentative	TNTV
terminal	TRML
terminate	TERM
territory	TRTY

[2] To be used in weather reports only.
[7] Symbol to be used to show obstruction to vision in weather reports only, and should be shown in report immediately following the visibility. The symbols E., S., and SW. shall not be shown in the remarks of a weather report to symbolize sleet, snow or snow showers.

Words and phrase contractions—Continued

thereafter	THRFTR
thick	THK
thin	THN
thousand	THSD
threaten	THTN
through	THRU
throughout	THRUT
thunder	THDR
thunderhead	THD
thundershower	TSHWR
thunderstorm	TSTM
thunderstorm [2]	T
ticket	TKT
today	TDA
tomorrow	TMW
tonight	TNGT
topping	TPG
toward	TWD
tower	TWR
traffic	TFK
transatlantic	TSATLC
transfer	TSFR
transform	TSFRM
transmission	TSMTN
transmit	TSMT
transpacific	TSPAC
transport	TSPT
travel	TVL
trouble	TRBL
turbulence	TURBC
turbulent	TURBT
twilight	TWI

taking balloon run	TABAL
telegraph (radio) communications interrupted	TELNO
telegraph (radio) communications resumed	TELOK
telegraph reply	TELRY
telephone company	TELCO
teletype communications interrupted	TYPNO
teletype communications resumed	TYPOK
top of overcast	TOVC
transfer ------ (name) from ------ (station) to ------ (station) travel at Government expense	TAGEX
transfer ------ (name) from ------ (station) to ------ (station) without expense to Government	TAWOG
twilight zone	TWIZN

unable	UNAB
United States	US
United States airway communications station	USACS
unlimited	UNL
unnecessary	UNEC
unquote	UQOT
unread	UNRD
unrestricted	UNRSTD
unsettle	UNSTL
unsteady	UNSTDY
until	TIL
unusual	UNUSL
upward	UPWD

you are authorized	URAUZ
your recommendation is approved	URECA
your recommendation is requested	URIZR
your recommendation is not approved	URNAP
until further notice	UFN
use runway	URNWY

valley	VLY
vapor	VPR
variable	VRBL
variable [2]	V

[2] To be used in weather reports only.

Words and phrase contractions—Continued

veering	VRG
velocity	VEL
verify	VFY
vicinity	VCNTY
violence	VLNC
violent	VLNT
visible	VSB
visibility	VSBY
vision	VSN
visibility reduced by smoke	VSRDBK
visibility restricted	VSRSTD
warm	WRM
weak	WK
weaken	WKN
weather	WEA
weight	WGT
westbound	WEBND
Western Plateau	WPLTO
whereabouts	WBTS
wind	WND
word	WD
work	WRK
worse	WRS
Weather Bureau	WB
will be forwarded	WIBFD
will be ordered	WIBOD
words per minute	WPM
Will you accept, if offered, position as principal communications operator, transfer at Government expense to (location)	WUPGE
Same—senior communications operator	WUSGE
Same—communications operator	WUCGE
Same—assistant communications operator	WUAGE
Same—junior communications operator	WUJGE
Same—under communications operator	WUUGE
Same—relief under communications operator	WURGE
Same—emergency relief communications operator	WUEGE
Will you accept, if offered, position as principal communications operator, transfer without expense to Government, to (location)	WUPNO
Same—senior communications operator	WUSNO
Same—communications operator	WUCNO
Same—assistant communications operator	WUANO
Same—junior communications operator	WUJNO
Same—under communications operator	WUUNO
Same—relief under communications operator	WURNO
Same—emergency relief communications operator	WUENO
Will you accept, if offered, position as principal radio electrician, transfer at Government expense, to (location)	WUFPEG
Same—senior radio electrician	WUFSEG
Same—radio electrician	WUFREG
Same—principal radio electrician (maintenance)	WUMPEG
Same—senior radio electrician (maintenance)	WUMSEG
Same—radio electrician (maintenance)	WUMREG
Will you accept, if offered, position as principal radio electrician, transfer without expense to Government, to (location)	WUFPEN
Same—senior radio electrician	WUFSEN

Words and phrase contractions—Continued

Same—radio electrician	WUFREN
Same—principal radio electrician (maintenance)	WUMPEN
Same—senior radio electrician (maintenance)	WUMSEN
Same—radio electrician (maintenance)	WUMREN
Will accept, if offered, position as principal communications operator, transfer at Government expense to (location)	WAPGE
Same—senior communications operator	WASGE
Same—communications operator	WACGE
Same—assistant communications operator	WAAGE
Same—junior communications operator	WAJGE
Same—under communications operator	WAUGE
Same—relief under communications operator	WARGE
Same—emergency relief communications operator	WAEGE
Will accept, if offered, position as principal communications operator, transfer without expense to Government to (location)	WAPNO
Same—senior communications operator	WASNO
Same—communications operator	WACNO
Same—assistant communications operator	WAANO
Same—junior communications operator	WAJNO
Same—under communications operator	WAUNO
Same—relief under communications operator	WARNO
Same—emergency relief communications operator	WAENO
Will accept, if offered, position as principal radio electrician, transfer at Government expense to (location)	WAFPEG
Same—senior radio electrician	WAFSEG
Same—radio electrician	WAFREG
Same—principal radio electrician (maintenance)	WAMPEG
Same—senior radio electrician (maintenance)	WAMSEG
Same—radio electrician (maintenance)	WAMREG
Will accept, if offered, position as principal radio electrician, transfer without expense to Government to (location)	WAFPEN
Same—senior radio electrician	WAFSEN
Same—radio electrician	WAFREN
Same—principal radio electrician (maintenance)	WAMPEN
Same—senior radio electrician (maintenance)	WAMSEN
Same—radio electrician (maintenance)	WAMREN

yesterday	YDA
Yukon	YKN
Yukon Standard (time) [1]	Y

Abbreviations and phrase contractions alphabetically listed with meanings

A [2]	hail
A [1]	Alaskan Standard (time)
AAA	All American Aviation Incorporated
AAL	American Airlines
ABC	Atlanta Birmingham & Coast (RR)
ABNDC	abundance
ABNML	abnormal

[1] When used immediately at end of a four-figure time group.
[2] To be used in weather reports only.

Abbreviations and phrase contractions alphabetically listed with meanings—Con.

ABRD	aboard
ABSB	absorb
ABT	about
ABV	above
AC	altocumulus
ACC	altocumulus castellatus
ACCT	account
ACELT	accelerate
ACFT	aircraft
ACK	acknowledge
ACL	Atlantic Coast Line (RR)
ACMLT	accumulate
ACPT	accept
ACPY	accompany
ACRD	accord
ACRS	across
ACS	Airline Charter Service.
ACTG	acting
ACTN	action
ACTV	active
ADCON	advise or issue instructions to all concerned
ADEDA	advise effective date
ADJN	adjoin
ADJT	adjacent
ADN	addition
ADQT	adequate
ADRNDCK	Adirondack
ADS	address
ADVC	advice
ADVN	advance
ADVOF	advise this office
ADVR	adverse
ADVZ	advise
ADVZY	advisory
AEA	American Export Airlines
AERLGL	aerological
AERLY	aerology
AERNL	aeronautical
AFCT	affect
AFM	affirm
AFP	alternate flight plan
AFS	Airline Feeder System
AFT	after
AFTN	afternoon
AGN	again
AGRS	aggress
AHD	ahead
ALA	Alabama
ALF	aloft
ALG	along
ALGHNY	Alleghany
ALLAO	all assistant communications operators
ALLCO	all communications operators
ALLER	all emergency relief communications operators
ALLJO	all junior communications operators
ALLPO	all principal communications operators
ALLRU	all relief under communications operators
ALLSO	all senior communications operators
ALLUO	all under communications operators
ALSK	Alaska
ALSTG	altimeter setting
ALT	altitude
ALTA	Alberta
ALTF	alternate field
ALTN	alternate
ALUTN	Aleutian
AM	ante meridian
AMAFA	air mass and frontal analysis
AMGT	amalgamate
AMO	air mail operations
AMS	air mass
AMT	amount
ANCPT	anticipate
ANLGS	analogous
ANLYS	analysis
ANLZ	analyze
ANRA	Air Navigation Radio Aids
ANS	answer

Abbreviations and phrase contractions alphabetically listed with meanings—Con.

ANT	antenna
ANTHR	another
AP [2]	small hail
APAF	no airplane observation, aerometeorograph failure
APCH	approach
APDL	airplane observation delayed, to be transmitted later
APFD	no airplane observation, field unsafe or closed
APFI	airplane observation not filed
APLCHN	Appalachian
APLO	no airplane observation, maximum altitude below 500 m. above ground
APNT	appoint
APOBS	airplane weather observations
APPI	no airplane observation, no pilot available
APPR	appear
APR	April
APREQ	approval requested
APRT	apparent
APRX	approximate
APT	Airport Control Tower
APTNO	airport control tower radio facilities not operating
APTOK	airport control tower radio facilities resumed operation
APV	approve
APWE	no airplane observation, unfavorable weather
APXX	no airplane observation for any reason not given above
ARBTY	arbitrary
ARCA	Aeronca
ARDO	Army radio
ARIZ	Arizona
ARK	Arkansas
ARND	around
ARNG	arrange
ARPT	airport
ARR	Alaska Railroad
ARV	arrive
AS	altostratus
ASCD	ascend
ASCO	Alaska Steamship Company
ASCT	ascent
ASGN	assign
ASM	assume
ASMN	assumption
ASOCT	associate
ASSAP	as soon as practicable
ATC	airway traffic control
ATCH	attach
ATLC	Atlantic
ATMT	attempt
ATND	attend
ATNNO	attention signal is not operating
ATNOK	attention signal has resumed operation
ATS	Atchison, Topeka & Santa Fe (RR)
ATSPH	atmosphere
ATT	American Telephone and Telegraph Company
AUG	August
AUGRA	authority granted
AURBO	Aurora Borealis
AUTO	automatic
AUX	auxiliary
AUZ	authorize
AUZRE	authority is requested
AVE	avenue
AVG	average
AVL	avail
AWEA	account weather
AWO	Airways Weather Office
AWY	airway
B [1]	Bearing Standard (time)

[1] When used immediately at end of a four-figure time group.
[2] To be used in weather reports only.

Abbreviations and phrase contractions alphabetically listed with meanings—Con.

BAA	Bangor & Aroostock (RR)
BAG	baggage
BAM	Boston & Maine (RR)
BAO	Baltimore & Ohio (RR)
BC	British Columbia
BCK	back
BCFT	Beechcraft
BCM	become
BCN	beacon
BCTOVC	broken clouds to overcast
BD [2]	blowing dust
BDA	Bermuda
BDC	broadcast
BDR	border
BEBNR	beacon light burning but not revolving until further notice
BEBOK	beacon resumed normal operation
BENBU	beacon light not burning until further notice
BFR	before
BGN	begin
BINOVC	breaks in overcast
BL	bill of lading
BLC	balance
BLCA	Bellanca
BLD	build
BLE	Bessemer & Lake Erie (RR)
BLK	black
BLKHLS	Blackhills
BLKT	blanket
BLO	below
BLP	bomber landplane
BLST	ballast
BLW	blow
BN [2]	blowing sand
BND	bound
BNDRY	boundary
BNF	Braniff Airways
BNTH	beneath
BOIG	Boeing
BRD	board
BRGT	bright
BRK	break
BRKN	broken
BRKSHR	Berkshire
BRM	barometer
BRMC	barometric
BRONO	broadcast not operating until further notice
BROOK	broadcast resumed operation
BRP	Buffalo, Rochester & Pittsburgh (RR)
BS [2]	blowing snow
BSP	bomber seaplane
BTR	better
BTWN	between
BULET	bureau letter
BYD	beyond
C [1]	Central Standard (time)
C [4]	contact
C [3]	calm
CAA	Civil Aeronautics Administration
CAL	Continental Air Lines
CALIF	California
CAN	Canada
CAO	Chesapeake & Ohio (RR)
CAPT	captain
CARCTR	character
CARCTRC	characteristic
CAS	Colorado & Southern (RR)
CASCDS	Cascades
CAUFN	caution advised until further notice
CAVU	ceiling and visilbiity unlimited
CB	cumulonimbus

[1] When used immediately at end of a four-figure time group.
[2] To be used in weather reports only.
[3] When used in wind velocity position of symbol weather report.
[4] When used in symbol weather report, following station identification. to indicate weather classification.

Abbreviations and phrase contractions alphabetically listed with meanings—Con.

CBQ	Chicago, Burlington & Quincy (RR)
CC	cirrocumulus
CCA	Canadian Colonial Airways
CDNS	condense
CEI	Chicago & Eastern Illinois (RR)
CFM	confirm
CFN	confine
CFR	contact flight rule
CGA	Chicago & Alton (RR)
CGRDO	Coast Guard radio
CGW	Chicago Great Western (RR)
CHG	change
CHI	Chicago & Southern Air Lines
CHSPK	Chesapeake
CHTR	charter
CI	cirrus
CIG	ceiling
CIGUN	ceiling unrestricted
CIL	Chicago, Indianapolis & Louisville (RR)
CIR	circular
CK	check
CKT	circuit
CLB	climb
CLD	cloud
CLKWZ	clockwise
CLOTO	close this office
CLR	clear
CLZ	close
CM	cumulonimbus mammatus (mammato-cumulus)
CMCT	communicate
CMNC	commence
CMPS	compass
CMPT	compartment
CMRC	commerce
CMS	Chicago, Milwaukee, St. Paul & Pacific (RR)
CMSN	commission
CNA	Canadian Airways
CNCL	cancel
CND	condition
CNDN	Canadian
CNJ	Central Railroad of New Jersey
CNP	Cincinnati, New Orleans & Texas Pacific (RR)
CNT	connect
CNTR	center
CNTRCLKWZ	counterclockwise
CNTRL	central
CNVCTN	convection
CNVCTV	convective
CNVRG	converge
CNW	Chicago & Northwestern (RR)
CO	Commanding Officer
CO	company
COG	Central of Georgia (RR)
COL	colonel
COLO	Colorado
COMDR	commander
COMDT	commandant
COMP	complete
CONN	Connecticut
CONST	construct
CONT	continue
COREQ	confirming requisition follows
COV	Central Vermont (RR)
CONTDVD	Continental Divide
CPTY	capacity
CPZ	compose
CQN	correction
CQT	correct
CRC	circle
CRI	Chicago, Rock Island & Gulf (RR)
CROS	cross
CRP	Chicago, Rock Island & Pacific (RR)
CRS	course
CRZ	cruise
CS	cirrostratus
CSDR	consider
CSO	Chicago, St. Paul, Minneapolis & Omaha (RR)

Abbreviations and phrase contractions alphabetically listed with meanings—Con.

CST	coast
CSTGRD	Coast Guard
CTC	contact
CTL	control
CTN	caution
CTSCLDS	clear to scattered clouds
CTSKLS	Catskills
CU	cumulus
CVA	Central Vermont Airways
CVR	cover
CYL	cylinder
D [2]	dust
D [1]	departed
DABRK	daybreak
DAH	Delaware & Hudson (RR)
DAL	Delta Airlines
DALGT	daylight
DBL	double
DBT	doubt
DBTF	doubtful
DC	District of Columbia
DCLN	decline
DCRS	decrease
DEC	December
DEL	Delaware
DFN	define
DFNT	definite
DFQ	day frequency
DFS	disregard former service
DGLS	Douglas
DGNL	diagonal
DGR	danger
DGRE	degree
DHD	deadhead
DIREP	dispatch reply
DIS	dispatch
DIST	district
DKTS	Dakotas
DLA	delay
DLVR	deliver
DLW	Delaware, Lackawanna & Western (RR)
DMN	Duluth, Missabe & Northern (RR)
DMNST	demonstrate
DMNT	dominant
DMSH	diminish
DNS	dense
DOC	Department of Commerce
DPEN	deepen
DPLN	deplane
DPND	depend
DPRS	depress
DPT	depart
DPTR	departure
DPTH	depth
DRBT	distribute
DRCT	direct
DRFT	drift
DRG	Denver & Rio Grande Western (RR)
DRK	dark
DRP	drop
DRZL	drizzle
DSA	Duluth, South Shore & Atlantic (RR)
DSCONT	discontinue
DSGNT	designate
DSIPT	dissipate
DSND	descend
DSNT	distant
DSPLC	displace
DSPN	disposition
DSR	desire
DSRGRD	disregard
DSTB	disturb
DSTC	distance
DSTN	destination
DTCT	detect
DTI	Detroit, Toledo & Ironton (RR)
DTN	detain
DTRN	detrain
DUPE	duplicate
DURG	during
DURN	duration
DVLP	develop

[1] When used immediately preceding a four-figure time group.
[2] To be used in weather reports only.

Abbreviations and phrase contractions alphabetically listed with meanings—Con.

DVN	division
DVRG	diverge
DVT	deviate
DW	delayed weather
DWNWD	downward
DWPNT	dew point
E [1]	Eastern Standard (time)
E [5]	estimated
E [7]	sleet
EABND	eastbound
EAL	Eastern Air Lines
EFCT	effect
EJE	Elgin, Joliet & Eastern (RR)
ELKA	Electra
ELMT	eliminate
ELNGT	elongate
ELSW	elsewhere
ELTC	electric
ELV	elevate
EMGCY	emergency
ENCTR	encounter
ENDR	endure
ENGN	engine
ENRT	en route
ENTR	entire
ENVP	envelope
EOD	entered on duty
EPSTM	elapsed time
EQLZ	equalize
EQP	equip
ERR	Erie Railroad
ESNTL	essential
ESTBL	establish
ETA	estimated time of arrival
ETC	et cetera
ETD	estimated
ETE	estimated time en route
ETOV	estimated time over
ETP	estimated time of departure
EVE	evening
EVPT	evaporate
EXREP	expedite mail reply
EXSHI	expedite shipment
F [2]	fog
F— [2]	damp haze
FAD	Fort Worth & Denver City (RR)
FAFON	fan type marker found operating normally
FAIRAC	fair and colder
FAIRACC	fair and continued cold
FAIRAW	fair and warmer
FAIRACW	fair and continued warm
FANHD	fan type marker not heard
FANOT	fan type marker not operative until further notice
FAROK	fan type marker resumed operation
FAS	Federal Airways Service
FC	fractocumulus
FCLD	Fairchild
FCST	forecast
FCTY	factory
FEB	February
FEC	Florida East Coast (RR)
FED	federal
FFLT	familiarization flight
FILLI	field and lighting facilities
FINAC	field notice to airmen is current

[1] When used immediately at end of a four-figure time group.
[2] To be used in weather reports only.
[5] Used immediately preceding a ceiling height or following a wind velocity value in a symbol weather report.
[7] To be used to show obstruction to vision in weather reports only, and should be shown in report immediately following the visibility. The symbols E., S. and SW. shall not be shown in the remarks of a weather report to symbolize sleet, snow or snow showers.

Abbreviations and phrase contractions alphabetically listed with meanings—Con.

FINO	hourly sequence weather report not filed
FLA	Florida
FLD	field
FLG	falling
FLP	fighter landplane
FLRY	flurry
FLT	flight
FLW	follow
FOCOR	forward confirming requisition
FORNN	forenoon
FPLN	flight plan
FPM	feet per minute
FQCY	frequency
FQT	frequent
FRI	Friday
FRM	form
FRSH	fresh
FRST	frost
FRZ	freeze
FRZN	frozen
FS	fractostratus
FSP	fighter seaplane
FSW	Fort Smith & Western (RR)
FT	feet; foot; fort
FTHR	farther; further
FTNX	full tanks
FVR	favor
FWD	forward
G [1]	Greenwich civil (time)
GA	Georgia.
GAL	gallon
GAS	gasoline
GBA	give better address
GF [2]	ground fog
GHQ	general headquarters
GLF	gulf
GLFMEX	Gulf of Mexico
GLFSTLAWR	Gulf of Saint Lawrence.
GND	ground
GNDFG	ground fog
GNRL	general
GNRT	generate
GOVT	government
GQA	get quick answer
GRBNKS	Grand Banks
GRDL	gradual
GRMN	Grumman
GRN	Great Northern (RR)
GRP	group
GRR	Georgia Railroad
GRT	great
GRTLKS	Great Lakes
GRTPLNS	Great Plains
GS [2]	drifting snow
GST	gust
GTW	Grand Trunk Western (RR)
GYB	Greyhound Bus
H [2]	hazy
H [1]	Hawaiian Standard (time)
HD	head
HDQTRS	headquarters
HDWND	headwind
HI	high
HIWA	highway
HLD	hold
HLF	half
HMD	humid
HND	hundred
HNG	hang
HR	hour
HRZN	horizon
HURCN	hurricane
HVY	heavy
HWI	Hawaii
HYDRO	hydrographic
HZY	hazy
IA	Iowa
ICG	icing
ICGIC	icing in clouds
ICGIP	icing in precipitation
IDA	Idaho
IDNFCN	identification
IDNFY	identify
IF [2]	ice fog
IFN	information
IFR	instrument flight rule

[1] When used immediately at end of a four-figure time group.
[2] To be used in weather reports only.

Abbreviations and phrase contractions alphabetically listed with meanings—Con.

IGN	International-Great Northern (RR)
ILC	Illinois Central (RR)
ILL	Illinois
IMDT	immediate
IMPT	important
IMPTC	importance
INADQT	inadequate
INC	incorporate
INCL	include
INCLV	inclusive
INCOMP	incomplete
INCQT	incorrect
INCR	increase
IND	Indiana
INDC	indicate
INDFNT	indefinite
INL	Inland Air Lines
INREQ	information requested
INSP	inspect
INST	instruct
INSTL	install
INSTMT	instrument
INTL	initial
INTMD	intermediate
INTMT	intermittent
INTR	interior
INTRP	interrupt
INTS	intense
INVSGT	investigate
INTSX	intersect
IOVC	in the overcast
IPV	improve
IREG	irregular
ISL	island
ITVL	interval
JAN	January
JCTN	junction
JUL	July
JUN	June
K [2]	smoke
KAFMXD	smoke and fog mixed
KAN	Kansas
KC	kilocycle
KOG	Kansas, Oklahoma & Gulf (RR)
KOL	Kollsman
KSO	Kansas City Southern (RR)
KW	kilowatt
KWTN	Keewatin
KY	Kentucky
L [1]	drizzle
LA	Louisiana
LAB	laboratory
LAN	Louisville & Nashville (RR)
LAS	Los Angeles & Salt Lake (RR)
LATD	latitude
LATDNL	latitudinal
LBRDR	Labrador
LCL	local
LCT	locate
LCTMP	little change in temperature
LCZR	localizer
LETFO	letter follows
LEV	leave
LFC	Lake Erie, Franklin-Clarion (RR)
LFT	lift
LGT	light
LKHD	Lockheed
LKLY	likely
LMT	limit
LND	land
LNGD	longitude
LNGDNL	longitudinal
LOI	Long Island (RR)
LP	landplane
LSCB	Luscombe
LT	lieutenant
LTCOMDR	lieutenant commander
LTNG	lightning
LTR	later
LTTR	latter
LVA	Lehigh Valley (RR)
LVL	level
LWR	lower
LYR	layer

[1] When used immediately at end of a four-figure time group.
[2] To be used in weather reports only.

Abbreviations and phrase contractions alphabetically listed with meanings—Con.

M [1]	Mountain Standard (time)
M [6]	missing
MAJ	major
MAL	Marquette Air Lines
MANOP	Manual of Operations
MANT	Manitoba
MAO	Mobile & Ohio (RR)
MAR	March
MASS	Massachusetts
MAX	maximum
MAY	May
MCE	Maine Central (RR)
MCK	mechanic
MCKN	mechanician
MCKNZ	Mackenzie
MD	Maryland
MDT	moderate
ME	Maine
METGL	meteorological
MEX	Mexico
MEXN	Mexican
MGR	manager
MHDG	magnetic heading
MI	mile
MICH	Michigan
MID	middle
MIDN	midnight
MIM	minimum
MIN	minute
MINN	Minnesota
MISG	missing
MISS	Mississippi
ML	mail
MNTN	maintain
MNTNC	maintenance
MO	Missouri
MON	Monday
MONT	Montana
MOV	move
MPH	miles per hour
MPM	Minneapolis, St. Paul & Sault Ste. Marie (RR)
MR	Mister
MRK	mark
MRNG	morning
MRS	Mistress
MRTM	maritime
MSG	message
MSL	mean sea level
MSS	Minneapolis & St. Louis (RR)
MST	most
MSTK	mistake
MSTR	moisture
MTN	mountain
MTRL	material
MTT	Missouri-Kansas-Texas of Texas (RR)
MVA	Midland Valley (RR)
MXD	mixed
N [4]	instrument
NACOS	National Communication System
NAL	National Airlines
NAV	navigation
NAW	Norfolk & Western (RR)
NB	New Brunswick
NBRHD	neighborhood
NC	North Carolina
NCL	Nashville, Chattanooga & St. Louis (RR)
NCS	New York-Chicago & St. Louis (RR)
ND	North Dakota
NEA	Northeast Airlines
NEB	Nebraska
NEC	necessary
NEV	Nevada
NF	Newfoundland
NFQ	night frequency
NGT	night
NH	New Hampshire
NJ	New Jersey
NM	New Mexico
NMRS	numerous

[1] When used immediately at end of a four-figure time group.
[4] Used in symbol weather report, following station identification, to indicate weather classification.
[6] Used in symbol weather reports in place of element ordinarily reported.

Abbreviations and phrase contractions alphabetically listed with meanings—**Con.**

NNH	New York, New Haven & Hartford (RR)
NOBND	northbound
NOMUCHTMP	not much change in temperature
NOOPV	not operative
NOP	Northern Pacific (RR)
NOQSC	not quite so cold
NORDO	no radio
NORXP	no reply received
NOTAM	Notice to Airmen
NOTOX	not to exceed
NOV	November
NOW	New York, Ontario & Western (TT)
NRAB	Naval Reserve Air Base
NRDO	Navy radio
NRML	normal
NS	nimbostratus
NS	Nova Scotia
NSO	Norfolk Southern (RR)
NSRD	no space reserved
NSRL	no space released
NUM	number
NVR	never
NVRMD	nevermind
NWA	Northwest Airlines
NWENG	New England
NXT	next
NY	New York
NYC	New York Central (RR)
NYD	Navy Yard
OAA	Oklahoma City, Ada & Atoka (RR)
OBS	observe
OBSC	obscure
OBST	obstruct
OCLD	occlude
OCN	occasion
OCT	October
OCUR	occur
OHIO	Ohio
OKLA	Oklahoma
OLP	observation land plane
ONT	Ontario
OPM	operations per minute
OPT	operate
ORDR	order
OREG	Oregon
OSP	observation seaplane
OSL	Oregon Short Line (RR)
OTI	on time
OTP	on top
OTR	other
OTRW	otherwise
OVC	overcast
OVD	overdue
OVHD	overhead
OVNGT	overnight
OVR	over
OVRN	overrun
OVTK	overtake
OWC	Oregon-Washington (RR) & Navigation Co.
OZ	ounce
P [8]	proposed departure
P [1]	Pacific Standard (time)
PA	Pennsylvania
PAA	Pan-American Airways
PAA	Pacific Alaska Airways (subsidiary of Pan-American Airways)
PAC	Pacific
PANCOM	Pan - American Airways communications office
PANMET	Pan - American Airways meteorological office
PARA	paragraph
PBL	probable

[1] When used immediately at end of a four-figure time group.
[8] When used immediately preceding a four-figure time group.

Abbreviations and phrase contractions alphabetically listed with meanings—Con.

PCA	Pennsylvania Central Airlines
PCH	pouch
PCPL	principal
PCPN	precipitation
PCS	piece
PECD	precede
PGRS	progress
PGTSND	Puget Sound
PIBA	no pilot balloon observation, no balloons
PIBAL	pilot balloon sequence reports
PICO	no pilot balloon observation, low clouds
PIDU	no pilot balloon observation, thick dust
PIFI	pilot balloon observation not filed
PIFO	no pilot balloon observation, foggy
PIHE	no pilot balloon observation, no gas
PIIO	no pilot balloon observation, instrument trouble
PIKO	no pilot balloon observation, smoky
PIRA	no pilot balloon observation, raining
PIREPS	pilot reports
PISE	no pilot balloon observation, unfavorable sea conditions
PISO	no pilot balloon observation, snowing
PIWI	no pilot balloon observation, high or gusty surface wind
PLE	Pittsburgh & Lake Erie (RR)
PLP	patrol landplane
PM	post meridian
PMQ	Pere Marquette (RR)
PMSN	permission
PMT	permit
PND	pound
PNHDL	Panhandle
PNT	point
PNTRT	penetrate
PO	post office
POCD	proceed
POLAT	polar Atlantic
POLCO	polar continental
POLPA	polar Pacific
POWNO	power supply failure
POWOK	power supply restored
PRCL	parcel
PRD	period
PRES	pressure
PROP	propeller
PRR	Pennsylvania Railroad
PRST	persist
PSBL	possible
PSE	please
PSG	passing
PSGR	passenger
PSN	position
PSP	patrol seaplane
PTC	plan to clear
PTCH	patch
PTK	protect
PTLY	partly
PTN	portion
PTT	Pacific Telephone and Telegraph Company
PUBSH	publish
PUP	pickup
PVL	prevail
PVLT	prevalent
PWR	power
QK	quick
QNTY	quantity
QOK	Quincy, Omaha & Kansas City (RR)
QOT	quote
QT	quiet; quart
QTR	quarter
QUAD	quadrant
QUE	Quebec

Abbreviations and phrase contractions alphabetically listed with meanings—Con.

R [2]	rain
R [8]	returned
RABA	no radiosonde observation, no balloons on hand
RABT	no radiosonde observation, no batteries on hand
RACFI	radio and communication facilities not operative until further notice
RACFO	radio and communication facilities operative
RACOM	radio and communication facilities
RADI	no radiosonde observation, instrument disabled in launching
RADL	radiosonde observation delayed, to be transmitted later
RAFI	no radiosonde observation filed
RAGOK	radio range resumed operation
RAHE	no radiosonde observation, no gas on hand
RAIF	no radiosonde observation, instrument failure
RALO	no radiosonde observation, maximum altitude less than 500 meters above ground
RANAC	radio facilities notice to airmen is current
RANOT	radio range not operating until further notice
RAOBS	radiosonde observations
RARA	no radiosonde obser vation, no radic sondes on hand
RARAU	radio range appear unreliable
RARF	no radiosonde obser vation, recorder fai ure
RAWE	no radiosonde obser vation, unfavorabl weather
RAXX	no radiosonde obser vation for any rea son not given abov
RCH	reach
RCKY	Rocky
RCMD	recommend
RCO	Reading Company (RR)
RCV	receive
RCVNO	radio receiving facilities not operative until further notice
RCVOK	radio receiving facilities resumed operation
RDG	ridge
RDO	radio
RE	reference
REBUL	reference instruction bulletin
RECOK	recommend approval
RECON	reference contract
REDIS	reference dispatch
REFEN	reference endorsement
REG	register
REINV	reference invoice
RELET	reference letter
REMAG	reference mailgram
RENOA	reference Notice to Airmen
REPHO	reference our telephone conversation
REPRO	reference proposal
REQ	request

[2] Symbol to be used in weather reports only.
[8] When used immediately preceding a four-figure time group.

Abbreviations and phrase contractions alphabetically listed with meanings—Con.

REREQ	reference requisition
RETEL	reference telegram
REVL	reveal
RFL	refuel
RFP	Richmond, Fredericksburg & Potomac (RR)
RFS	refuse
RGD	ragged
RGLR	regular
RGLT	regulate
RGN	region
RGRD	regard
RGT	right
RI	Rhode Island
RIS	Rock Island Southern (RR)
RLA	relay
RLF	relief
RLS	release
RLV	relieve
RMD	remind
RMN	remain
RMRK	remark
RMV	remove
RNG	range
RNWY	runway
RO	regional office
ROCON	reference this office contract
RODIS	reference dispatch from this office
ROEND	reference endorsement from this office
ROINV	reference invoice from this office
ROLET	reference letter from this office
ROMAG	reference mailgram from this office
RONLY	receiving only
RONOA	reference this office Notice to Airmen
ROREQ	reference requisition from this office
ROTEL	reference telegram from this office
ROVNGT	remaining overnight
RPD	rapid
RPL	replace
RPRT	report
RPT	repeat
RQ [2]	rain squall
RQN	requisition
RQR	require
RR	railroad
RSG	rising
RSN	risen
RSOPN	resumed operation
RST	restrict
RSV	reserve
RSVN	reservation
RTE	route
RTN	return
RTRD	retard
RUCON	reference contract from your office
RUDIS	reference dispatch from your office
RUEND	reference endorsement from your office
RUF	rough
RUINV	reference invoice from your office
RULET	reference letter from your office
RUMAG	reference mailgram from your office
RUNOA	reference Notice to Airmen from your office
RUREQ	reference requisition from your office
RUT	Rutland (RR)
RUTEL	reference telegram from your office
RVR	river
RW [2]	rain showers
RYRQD	reply requested

[2] To be used in weather reports only.

Abbreviations and phrase contractions alphabetically listed with meanings—Con.

S [7]	snow
SACO	Santa Ana Steamship Co.
SAL	Seaboard Airline (RR)
SASK	Saskatchewan
SAT	Saturday
SBLD	subject load
SBM	Saint Louis-Brownsville & Mexico (RR)
SBSD	subside
SC	South Carolina
SC	stratocumulus
SCT	scatter
SCTR	sector
SD	South Dakota
SEC	second
SEP	September
SEQ	sequence
SFC	surface
SFCT	sufficient
SGST	suggest
SGT	sergeant
SHFT	shift
SHLW	shallow
SHWR	shower
SIERNEV	Sierra Nevada
SIG	signature
SISKY	Siskiyou
SIT	situate
SKJ	schedule
SKSY	Sikorsky
SLGT	slight
SLP	scout landplane
SLS	Saint Louis-Southwestern (RR)
SLT	sleet
SLW	slow
SMRY	summary
SMTM	sometime
SMWHT	somewhat
SNGL	single
SNW	snow
SOBND	southbound
SOP	Southern Pacific (RR)
SP	seaplane
SP [2]	snow pellets
SPEC	specification
SPKL	sprinkle
SPL	special
SPRD	spread
SPS	Spokane Portland & Seattle (RR)
SPT	separate
SQ [2]	snow squall
SQAL	squall
SQDN	squadron
SRCH	search
SRND	surround
SRR	Southern Railway
SRS	see our service
SRTMP	slowly rising temperature
SS	steamship
SSF	Saint Louis-San Francisco (RR)
SSP	scout seaplane
SST	Saint Louis Southwestern Texas (RR)
ST	stratus; street; saint
STA	state
STDRD	standard
STG	strong
STL	settle
STM	storm
STMN	Stearman
STN	station
STP	stop
STR	Star Air Lines
STRSPH	stratosphere
STSN	Stinson
STWD	steward
SUN	Sunday
SUNRS	sunrise
SUNST	sunset
SUPR	Superior
SUPT	superintendent

[2] To be used in weather reports only.
[7] Symbol to be used to show obstruction to vision in weather reports only, and should be shown in report immediately following the visibility. The symbols E, S, and SW shall not be shown in the remarks of a weather report to symbolize sleet, snow or snow showers.

Abbreviations and phrase contractions alphabetically listed with meanings—Con.

SUREQ	submit requisition
SVC	service
SVR	severe
SVRL	several
SW[7]	snow showers
SXN	section
SXNAC	sectional aeronautical chart
SYM	system
SYN	synoptic
SYS	see your service
T[2]	thunderstorm
TABAL	taking balloon run
TAGEX	transfer ---- (name) from ---- (station) to ---- (station) travel at Government expense
TAWOG	transfer ---- (name) from ---- (station) to ---- (station) travel without expense to Government.
TCA	Trans Canada Air Lines
TDA	today
TELCO	telephone company
TELNO	telegraph (radio) communications interrupted
TELOK	telegraph (radio) communications resumed
TELRY	telegraph reply
TENN	Tennessee
TERM	terminate
TEX	Texas
TFK	traffic
THD	thunderhead
THDR	thunder
THK	thick
THN	thin
THRFTR	thereafter
THRU	through
THRUT	throughout
THSD	thousand
THTN	threaten
THU	Thursday
TIL	until
TKOF	take (ing) off
TKT	ticket
TLFO	telephone
TLP	transport landplane
TLTP	teletype
TMP	temperature
TMW	tomorrow
TND	tend
TNDCY	tendency
TNGT	tonight
TNTV	tentative
TOVC	top of overcast
TPG	topping
TRBL	trouble
TRML	terminal
TRPAT	tropical Atlantic
TRPGU	tropical Gulf
TRPMA	tropical maritime
TRPPA	tropical Pacific
TRTY	territory
TSATLC	Transatlantic
TSFR	transfer
TSFRM	transform
TSHWR	thundershower
TSLPOL	transitional polar
TSLPOLAT	transitional polar Atlantic
TSLPOLCO	transitional polar continental
TSLPOLPA	transitional polar Pacific
TSLTRPAT	transitional tropical Atlantic
TSLTRPGU	transitional tropical Gulf

[2] To be used in weather reports only.
[7] Symbol to be used to show obstruction to vision in weather reports only, and should be shown in report immediately following the visibility. The symbols E, S, and SW shall not be shown in the remarks of a weather report to symbolize sleet, snow or snow showers.

Abbreviations and phrase contractions alphabetically listed with meanings—Con.

TSLTRPMA	transitional tropical maritime
TSLTRPPA	transitional tropical Pacific
TSMT	transmit
TSMTN	transmission
TSP	transport seaplane
TSPAC	Transpacific
TSPT	transport
TSTM	thunderstorm
TUE	Tuesday
TURBC	turbulence
TURBT	turbulent
TVL	travel
TWA	Transcontinental & Western Air Inc.
TWD	toward
TWI	twilight
TWIZN	twilight zone
TWR	tower
TXN	Texas & New Orleans (RR)
TXP	Texas & Pacific (RR)
TYPNO	teletype communications interrupted
TYPOK	teletype communications resumed
UAL	United Airlines
UFN	until further notice
ULP	utility landplane
UNAB	unable
UNEC	unnecessary
UNL	unlimited
UNP	Union Pacific (RR)
UNRD	unread
UNRSTD	unrestricted
UNSTDY	unsteady
UNSTL	unsettle
UNT	Union Traction (RR)
UNUSL	unusual
UPWD	upward
UQOT	unquote
URAUZ	you are authorized
URECA	your recommendation is approved
URIZR	your recommendation is requested
URNAP	your recommendation not approved
URNWY	use runway
US	United States
USACS	United States Airway Communications Station
USP	utility seaplane
UTAH	Utah
V [2]	variable
VA	Virginia
VCNTY	vicinity
VEGA	Vega
VEL	velocity
VFI	verify
VLNC	violence
VLNT	violent
VLY	valley
VPR	vapor
VRBL	variable
VRG	veering
VRR	Virginian (RR)
VSB	visible
VSBY	visibility
VSN	vision
VSRDBK	visibility reduced by smoke
VSRSTD	visibility restricted
VT	Vermont

WAA	Woodley Airways
WAAGE	Will accept, if offered, position as assistant communications operator, transfer at Government expense to (location).
WAANO	Will accept, if offered, position as assistant communications operator, transfer without expense to Government to (location).
WACGE	Will accept, if offered, position as communications operator, transfer at Government expense to (location).

[2] To be used in weather reports only.

Abbreviations and phrase contractions alphabetically listed with meanings—Con.

WACNO	Will accept, if offered, position as communication operator, transfer without expense to Government to (location).
WACO	Waco.
WAEGE	Will accept, if offered, position as emergency relief communications operator, transfer at Government expense to (location).
WAENO	Will accept, if offered, position as emergency relief communications operator, transfer without expense to Government to (location).
WAFPEG	Will accept, if offered, position as principal radio electrician, transfer at Government expense to (location).
WAFPEN	Will accept, if offered, position as principal radio electrician, transfer without expense to Government to (location).
WAFREG	Will accept, if offered, position as radio electrician, transfer at Government expense to (location).
WAFREN	Will accept, if offered, position as radio electrician, transfer without expense to Government to (location).
WAFSEG	Will accept, if offered, position as senior radio electrician, transfer at Government expense to (location).
WAFSEN	Will accept, if offered, position as senior radio electrician, transfer without expense to Government to (location).
WAJGE	Will accept, if offered, position as junior communications operator, transfer at Government expense to (location).
WAJNO	Will accept, if offered, position as junior communications operator, transfer without expense to Government to (location).
WAL	Western Air Lines.
WAMPEG	Will accept, if offered, position as principal radio electrician (maintenance), transfer to Government expense to (location).
WAMPEN	Will accept, if offered, position as principal radio electrician (maintenance), transfer without expense to Government to (location).
WAMREG	Will accept, if offered, position as radio electrician (maintenance), transfer at Government expense to (location).
WAMREN	Will accept, if offered, position as radio electrician (maintenance), transfer without expense to Government to (location).
WAMSEG	Will accept, if offered, position as senior radio electrician (maintenance), transfer at Government expense to (location).
WAMSEN	Will accept, if offered, position as senior radio electrician (maintenance), transfer without expense to Government to (location).

Abbreviations and phrase contractions alphabetically listed with meanings—Con.

WAPGE	Will accept, if offered, position as principal communications operator, transfer at Government expense to (location).
WAPNO	Will accept, if offered, position as principal communications operator, transfer without expense to Government to (location).
WARGE	Will accept, if offered, position as relief under communications operator, transfer at Government expense to (location).
WARNO	Will accept, if offered, position as relief under communications operator, transfer without expense to Government to (location).
WASGE	Will accept, if offered, position as senior communications operator, transfer at Government expense to (location).
WASH	Washington.
WASNO	Will accept, if offered, position as senior communication operator, transfer without expense to Government to (location).
WAUGE	Will accept, if offered, position as under communications operator, transfer at Government expense to (location).
WAUNO	Will accept, if offered, position as under communications operator, transfer without expense to Government to (location).
WB	Weather Bureau
WBTS	whereabouts
WD	word
WEA	weather
WED	Wednesday
WEM	Western Maryland (RR)
WEP	Western Pacific (RR)
WEBND	westbound
WGT	weight
WIBFD	will be forwarded
WIBOD	will be ordered
WIS	Wisconsin
WK	weakness
WKN	weaken
WLE	Wheeling & Lake Erie (RR)
WND	wind
WPLTO	Western Plateau
WPM	words per minute
WRK	work
WRM	warm
WRR	Wabash (RR)
WRS	worse

Abbreviations and phrase contractions alphabetically listed with meanings—Con.

WUAGE	Will you accept, if offered, position as assistant communications operator, transfer at Government expense to (location).
WUANO	Will you accept, if offered, position as assistant communications operator, transfer without expense to Government to (location).
WUCGE	Will you accept, if offered, position as communications operator, transfer at Government expense to (location).
WUCNO	Will you accept, if offered, position as communications operator, transfer without expense to Government to (location).
WUEGE	Will you accept, if offered, position as emergency relief communications operator, transfer at Government expense to (location).
WUENO	Will you accept, if offered, position as emergency relief communications operator, transfer without expense to Government to (location).
WUFPEG	Will you accept, if offered, position as principal radio electrician, transfer at Government expense to (location).
WUFPEN	Will you accept, if offered, position as principal radio electrician, transfer without expense to Government to (location).
WUFREG	Will you accept, if offered, position as radio electrician, transfer at Government expense to (location).
WUFREN	Will you accept, if offered, position as radio electrician, transfer without expense to Government to (location).
WUFSEG	Will you accept, if offered, position as senior radio electrician, transfer at Government expense to (location).
WUFSEN	Will you accept, if offered, position as senior radio electrician, transfer without expense to Government to (location).
WUJGE	Will you accept, if offered, position as junior communications operator, transfer at Government expense to (location).
WUJNO	Will you accept, if offered, position as junior communications operator, transfer without expense to Government, to (location).
WUMPEG	Will you accept, if offered, position as principal radio electrician (maintenance), transfer at Government expense to (location).
WUMPEN	Will you accept, if offered, position as principal radio electrician (maintenance), transfer without expense to Government to (location).
WUMREG	Will you accept, if offered, position as radio electrician (maintenance), transfer at Government expense to (location).

Abbreviations and phrase contractions alphabetically listed with meanings—Con.

WUMREN	Will you accept, if offered, position as radio electrician (maintenance), transfer without expense to Government to (location).
WUMSEG	Will you accept, if offered, position as senior radio electrician (maintenance), transfer at Government expense to (location).
WUMSEN	Will you accept, if offered, position as senior radio electrician (maintenance), transfer without expense to Government to (location).
WUPGE	Will you accept, if offered, position as principal communications operator, transfer at Government expense to (location).
WUPNO	Will you accept, if offered, position as principal communications operator, transfer without expense to Government to (location).
WURGE	Will you accept, if offered, position as relief under communications operator, transfer at Government expense to (location).
WURNO	Will you accept, if offered, position as relief under communications operator, transfer without expense to Government to (location).
WUSGE	Will you accept, if offered, position as senior communications operator, transfer at Government expense to (location).
WUSNO	Will you accept, if offered, position as senior communications operator, transfer without expense to Government to (location).
WUUGE	Will you accept, if offered, position as under communications operator, transfer at Government expense to (location).
WUUNO	Will you accept, if offered, position as under communications operator, transfer without expense to Government to (location).
WVA	West Virginia.
WYO	Wyoming.

X [1]	closed
XAC	exact
XAM	examine
XCHG	exchange
XCP	except
XLNT	excellent
XPC	expect
XPDT	expedite
XPS	express
XST	exist
XTD	extend
XTL	crystal
XTRM	extreme
XTSN	extension
XTSV	extensive
Y [1]	Yukon Standard (time)
YDA	yesterday
YKN	Yukon
ZL [2]	freezing drizzle

[1] When used immediately at end of a four-figure time group.
[2] To be used in weather reports only.

Abbreviations and phrase contractions alphabetically listed with meanings—Con.

ZOFON	station location marker, ultra high frequency found operating normally
ZOHOK	station location marker, ultra high frequency resumed operation
ZONHD	station location marker, ultra high frequency not heard
ZONOT	station location marker, ultra high frequency not operating until further notice
ZR [1]	freezing rain

100. Station identifications and call letters.—*a. Alphabetically by call.*

Identification	Station	
AA	Alpena, Mich	A
AB	Albuquerque, N. Mex. (mun. arpt.)	*C*
AC	Anton Chico, N. Mex	*C*
AD	Upolu Point, T. H	*C*
AE	Alexandria, Minn	*C*
AF	Advance, Mo	*C*
AG	Atlanta, Ga. (mun. arpt.)	*C*
AJ	Alma, Ga	*C*
AK	Acomita, N. Mex	*C*
AL	Arlington, Oreg	*C*
AM	French Frigate Shoals, Pac	*C*
AN	Aberdeen, S. Dak. (mun. arpt.)	*C*
AO	Talkeetna, Alaska	*C*
AP	Abilene, Tex. (mun. arpt.)	*C*
AQ	Amarillo, Tex. (English Field)	*C*
AR	Auburn, Calif	*C*
AS	Anderson, S. C. (mun. arpt.)	*C*
AT	Ardmore, Okla	*C*
AU	Johnston Island, Pac	*C*
AV	Adairsville, Ga	*C*
AW	Augusta, Maine (state arpt.)	*C*
AX	Akron, Ohio (mun. arpt.)	*C*
AZ	Albany, N. Y. (mun. arpt.)	*C*
BA	Beowawe, Nev	*C*
BB	Bangor, Maine (mun. arpt.)	*C*
BC	Blue Canyon, Calif	*C*
BD	Bakersfield, Calif. (Kern County Arpt.)	*C*
BE	Boise, Idaho (Gowan Field)	*C*
BF	Bellefonte, Pa	*C*
BG	Big Springs, Nebr	*C*
BH	Birmingham, Ala. (mun. arpt.)	*C*
BI	Billings, Mont	*C*
BJ	Buffalo, N. Y. (mun. arpt.)	*C*
BK	Baker, Oreg	*C*
BL	Belgrade, Mont	*C*
BN	Burlington, Iowa (mun. arpt.)	*C*
BO	Baltimore, Md. (Logan Field)	*C*
BP	Bridgeport, Conn	*C*
BQ	Buckstown, Pa	*C*
BR	Brookville, Pa	*C*
BT	Butte, Mont	*C*
BU	Burbank, Calif. (Lockheed Air Terminal)	*C*
BV	Buffalo Valley, Nev	*C*
BW	Boston, Mass. (mun. arpt.)	*C*
BX	Burley, Idaho	*C*
BY	Barksdale Field, Shreveport, La	*W*
BZ	Big Spring, Tex. (mun. arpt.)	*C*
CA	Columbia, Mo. (mun. arpt.)	*C*
CB	Chattanooga, Tenn. (Lovell Field)	*C*
CC	Cincinnati, Ohio (Lunken Field)	*C*

[1] When used immediately at end of a four-figure time group.

Identification	Station	
CD	Belleville, Ill. (Scott Field Army Arpt.)	W
CE	Squaw Harbor, Alaska	C
CF	Charlotte, N. C. (Douglas mun. arpt.)	C
CG	Chicago, Ill. (mun. arpt.)	C
CI	Columbia, S. C. (mun. arpt.)	C
CJ	Cochise, Ariz	C
CM	Cambridge, Ohio	C
CN	Concord, N. H. (mun. arpt.)	C
CO	Columbus, Ohio (Port Columbus arpt.)	C
CP	Clarendon, Tex	C
CQ	Any or all comm. stations	
CR	Corpus Christi, Tex. (Cliff Maus Field)	C
CS	Charleston, S. C. (mun. arpt.)	C
CT	Youngstown, Ohio, (mun. arpt.)	C
CU	Custer, Mont	C
CV	Cleveland, Ohio (mun. arpt.)	C
CW	Casper, Wyo. (Wardwell Field)	C
CX	Cheyenne, Wyo. (mun. arpt.)	C
CY	Cassoday, Kans	C
CZ	Chanute, Kans. (mun. arpt.)	C
DB	Daytona Beach, Fla. (mun. arpt.)	C
DC	Dickinson, N. Dak	C
DE	Dillon, Mont	C
DG	Daggett, Calif	C
DH	Duluth, Minn. (Williamson-Johnson arpt.)	C
DI	Cold Bay (King Cove), Alaska	C
DJ	Losey Field, P. R	W
DK	Dunkirk, N. Y	C
DL	Dallas, Tex. (Love Field)	C
DM	Des Moines, Iowa (mun. arpt.)	C
DN	Salt Flat, Tex	C
DP	Wilmington, Del. (DuPont Arpt.)	A
DQ	Douglas, Wyo	
DR	Drummond, Mont	
DS	Donner Summit, Calif	
DT	Detroit, Mich. (Wayne County Arpt.)	
DV	Denver, Colo. (mun. arpt.)	
DW	Wake Island (PAC)	
DX	Mission, Tex	
DY	Dayton, Ohio (mun. arpt.)	
DZ	Dubois, Idaho	
EA	Elmira, N. Y	
EB	Ellensburg, Wash	
ED	Muscle Shoals, Ala. (TVA Arpt.)	
EE	Port Arthur, Tex	
EF	Effingham, Ill	
EH	Roswell, N. Mex	
EK	Elkins, W. Va. (mun. arpt.)	
EL	Elko, Nev. (mun. arpt.)	
EM	El Morro, N. Mex	
EO	El Paso, Tex. (mun. arpt.)	
EP	Ephrata, Wash	
EQ	Victorville, Calif	
ER	Erie, Pa. (Port Erie Arpt.)	
ET	Enid, Okla	
EU	Eugene, Ore. (mun. arpt.)	
EV	Evansville, Ind. (mun. arpt.)	
EX	Engle, N. Mex	
FA	Fort Davis, Panama	
FB	Brooklyn, N. Y. (Floyd Bennett Arpt.)	
FC	Cross City, Fla	
FE	Frontenac, Minn	
FF	Spring Bluff, Mo	
FH	Red Bluff, Calif. (Bidwell Arpt.)	
FI	Fort Sill, Okla. (Post Field)	
FJ	Fort Jones, Calif	
FK	Ashfork, Ariz	
FL	Florence, S. C. (mun. arpt.)	
FM	Fort Myers, Fla. (Lee County Arpt.)	

Identification	Station	
FO	Fargo, N. Dak. (Hector Field)	C
FT	Fresno, Calif. (mun. arpt.)	C
FU	Fond du Lac, Wis	A
FV	Fort Worth, Tex. (Meacham Field)	C
FW	Fort Wayne, Ind. (mun. arpt.)	C
FX	Fairbanks, Alaska	C
FY	Fort Riley, Kans. (Marshall Field)	W
FZ	Front Royal, Va	C
GA	Golva, N. Dak	C
GC	Greenville, S. C. (mun. arpt.)	A
GD	Greenwood, Miss	C
GE	Gainesville, Tex	C
GF	Grand Forks, N. Dak. (mun. arpt.)	C
GG	Gooding, Idaho	C
GH	Harvey, Ill	C
GI	Grand Island, Nebr. (mun. arpt.)	C
GJ	Gordonsville, Va	C
GK	Garden City, Kans. (mun. arpt.)	C
GL	Toledo, Wash	C
GM	Makena, Is. of Maui, (PAC)	C
GO	Goshen, Ind	C
GP	Guam Island, (PAC)	C
GR	Grand Rapids, Mich. (Kent County Arpt.)	C
GS	Galveston, Tex. (mun. arpt.)	C
GT	Great Falls, Mont	C
GV	Ottumwa, Iowa	C
GW	Greensboro, N. C. (Greensboro-Highpoint Arpt.)	C
GY	Albany, Ga. (mun. arpt.)	C
GZ	Lake Charles, La	W
HA	Hayesville, Ohio	C
HB	Long Beach, Calif. (mun. arpt.)	C
HD	Humboldt, Nev	C
HF	Hatbox Field (Muskogee, Okla)	W
HG	Moses Point, Alaska	C
HH	Lubbock, Tex	W
HI	Huntington, W. Va. (Mayes Field, Chesapeake, Ohio)	C
HJ	Houlton, Me. (mun. arpt.)	C
HK	Lincoln, Nebr. (Lindbergh Field)	A
HL	Helena, Mont	C
HM	Fort Bridger, Wyo	C
HN	Hutchinson, Kans. (mun. arpt.)	C
HO	Hamilton Field (Near San Rafael, Calif.)	W
HP	Kelso, Wash	C
HQ	Anchorage, Alaska (Merrill Field)	C
HR	Huron, S. Dak. (W. W. Howes Arpt.)	C
HT	Hartford, Conn. (Brainard Field)	C
HU	Houston, Tex. (Howard Hughes Arpt.)	C
HW	Crestview, Fla	C
HX	Harrisburg, Pa. (State arpt.)	C
HY	Hensley Fld., Ft. Worth, Tex	W
HZ	Honolulu, Oahu, T. H	C
IA	Williamsport, Pa. (mun. arpt.)	C
IB	Caribou, Me. (mun. arpt.)	C
IC	Moultrie, Ga	W
ID	Indianapolis, Ind. (mun. arpt.)	C
IF	Idaho Falls, Idaho	C
IG	Winder, Ga	C
IH	Borinquen, P. R	W
IK	Swan Island, Caribbean	C
IL	Philip, S. Dak	C
IM	Mather Field, Sacramento, Calif	W
IN	Indio, Calif	C
IP	San Angelo, Tex. (Goodfellow Field)	W
IQ	Lake Minchumina, Alaska	C
IR	Northbrook, Ill. (Sky Harbor)	D
IT	Lewistown, Mont	A

Identification	*Station*	
IU	La Grande, Oreg	*C*
IV	Ellington Field, Houston, Tex	*W*
IW	Willmar, Minn	*C*
IX	Iowa City, Iowa (mun. arpt.)	*A*
IY	Ilio, T. H	*C*
IZ	Atlantic, Iowa	*C*
JA	Jackson, Miss. (Hawkins Field)	*C*
JB	Bristol, Tenn. (Tri-City Arpt., McKellar Field)	*C*
JC	Battle Creek, Mich. (Kellogg Arpt.)	*C*
JD	Summit, Alaska	*C*
JE	Juneau, Alaska	*C*
JG	Burlington, Vt. (mun. arpt.)	*C*
JH	Stockton, Calif	*W*
JI	Brownsville, Tex. (Brownsville Pan-American Arpt.)	*C*
JJ	Bellingham, Wash. (Whatcom Co. Arpt.)	*C*
JK	Jacks Creek, Tenn	*C*
JM	Jamestown, N. Dak	*C*
JO	Joliet, Ill. (mun. arpt.)	*C*
JP	Iliamna, Alaska	*C*
JQ	Big Delta, Alaska	*C*
JR	Baton Rouge, La. (East Baton Rouge Parish Arpt.)	*C*
JS	Kenai, Alaska	*C*
JT	Lowry Field, Denver, Colo	*W*
JU	Beaumont, Tex. (mun. arpt.)	*C*
JV	Jarvis Island (PAC)	*C*
JW	Brinkley, Ark	*C*
JX	Jacksonville, Fla. (mun. arpt.)	*C*
JY	Palmyra Is. (PAC)	*C*
KA	Cordova, Alaska	*C*
KB	Hayes Center, Nebr	*C*
KC	Kansas City, Mo. (mun. arpt.)	*C*
KD	Naknek, Alaska	*C*
KE	Panama City, Fla	*W*

Identification	*Station*
KF	Kelly Field, San Antonio, Tex
KG	Ketchikan, Alaska
KI	Kingman, Ariz. (Port Kingman)
KJ	Valdez, Alaska
KL	Knoxville, Mo
KM	Midway Island (PAC)
KN	Charleston, W. Va. (Wertz Field)
KO	Couer d'Alene, Idaho (Weeks Field)
KQ	Neah Bay (Cape Flattery), Wash
KR	Kirksville, Mo
KS	Columbus, N. Mex
KT	Blackstone, Va. (mun. arpt.)
KW	Key West, Fla. (Meacham Arpt.)
KX	Knoxville, Tenn. (mun. arpt.)
KZ	Tanana, Alaska
LA	Los Angeles, Calif. (mun. arpt.)
LB	Lynchburg, Va. (Preston Glen Arpt.)
LC	Lake Charles, La. (mun. arpt.)
LD	Selfridge Field (Mt. Clemens, Mich.)
LE	LaCrosse, Wis
LF	LaFayette, Ind. (Purdue University Arpt.)
LG	LaGuardia Field, New York, N. Y
LH	La Junta, Colo. (mun. arpt.)
LI	Little Rock, Ark. (Adams Field)
LJ	Lansing, Mich. (Capitol City Arpt.)
LK	Lone Rock, Wis
LM	Livermore, Calif
LN	Lebo, Kans
LO	Locomotive Springs, Utah
LP	Lakehurst, N. J

Identification	Station	
LQ	Las Vegas, Nev. (McCarran Field)	C
LR	Laramie, Wyo. (mun. arpt.)	C
LS	St. Louis, Mo. (mun. arpt.)	C
LT	Livingston, Mont	C
LU	Farwell, Alaska	C
LV	Louisville, Ky. (Bowman Field)	C
LW	Sherman Field, Ft. Leavenworth, Kans	W
LY	Langley Field, Hampton, Va	W
LZ	Stevenson, Wash	C
MA	Madison, Wis. (mun. arpt.)	C
MC	Mercer, Pa	C
MD	Milford, Utah	C
ME	Monteagle, Tenn	C
MF	Medford, Oreg	C
MI	Everett, Wash. (Paine Field)	C
MJ	Black Moshannon, Pa	C
MK	Milwaukee, Wis. (Gen. Mitchell Field)	C
ML	McCool, Ind	C
MM	Miami, Fla. (mun. arpt.)	C
MN	Mullan Pass, Mont	C
MO	Moline, Ill. (mun. arpt.)	C
MP	Minneapolis, Minn. (Wold-Chamberlain Field)	C
MQ	Morse, Ill.	
MR	Martinsburg, W. Va. (Shepherd Arpt.)	C
MS	Mobile, Ala. (Bates Field)	C
MT	Millinocket, Maine (mun. arpt.)	C
MV	Milroy, Ind	C
MW	Maine, Ariz	C
MX	Missoula, Mont	C
MY	Miles City, Mont	C
MZ	Montezuma, Iowa	C
NA	Nashville, Tenn. (Berry Field)	C
NC	Pensacola, Fla. (U. S. Naval Air Station)	N
ND	Northdalles, Wash	C
NE	Gustavus, Alaska	C
NF	Niagara Falls, N. Y. (mun. arpt.)	A
NH	Newhall, Calif	C
NI	Dothan, Ala. (mun. arpt.)	C
NJ	Needles, Calif	C
NK	Newark, N. J. (mun. arpt.)	C
NL	Tuskegee, Ala	W
NN	Columbus, Miss	W
NO	New Orleans, La	C
NP	Enterprise, Utah	C
NQ	North Platte, Nebr. (mun. arpt.)	C
NR	Norfolk, Va. (Chambers Field)	N
NS	Neosho, Mo	C
NT	Navasota, Tex	C
NU	Chanute Field, Rantoul, Ill	W
NW	Norfolk, Va. (mun. arpt.)	C
NX	New Hackensack, N. Y	C
NZ	Mormon Mesa, Nev	C
OA	Oakland, Calif. (mun. arpt.)	C
OB	Canton Island, (PAC)	C
OC	Oceanside, Calif	C
OD	Modesto, Calif. (mun. arpt.)	C
OE	Howard Field, Canal Zone	W
OF	Kodiak, Alaska	C
OG	Ogden, Utah (mun. arpt.)	C
OH	Omaha, Nebr. (mun. arpt.)	C
OJ	Westover Field, Springfield, Mass	W
OL	Oklahoma City, Okla. (Will Rogers Field)	C
OM	Cape May, N. J	N
ON	Sloan Field, Midland, Tex	W
OO	Ontario, Oreg	C
OP	Pope Field (Fort Bragg, N. C.)	W
OQ	Nichols Field, P. I	W
OR	Orlando, Fla. (mun. arpt.)	C
OT	Otto, N. Mex	C
OU	Melbourne, Fla. (Melbourne-Eau Gallie Arpt.)	C
OV	Overton, Nebr	C
OW	Ottawa, Ont	CAN

Identification	Station	
OX	Biloxi, Miss. (Keesler Field)	C
OZ	Port Allen, Kauai, T. H	C
PA	Palmdale, Calif	C
PB	Pembina, N. Dak	C
PD	Portland, Oreg	C
PE	Perry, Ohio	C
PF	Port Washington, L. I., N. Y	
PG	Philadelphia, Pa. (mun. arpt.)	C
PH	Phoenix, Ariz. (Sky Harbor)	C
PI	Peoria, Ill. (mun. arpt.)	C
PK	Patterson Field, Dayton, Ohio	W
PM	Moose Creek, Alaska	C
PN	Putnam, Conn	C
PO	Pendleton, Oreg	C
PP	Selma, Ala	W
PQ	Pocatello, Idaho	C
PR	Providence, R. I. (R. I. State Arpt.)	A
PS	Memphis, Tenn. (mun. arpt.)	C
PT	Pittsburgh, Pa. (Allegheny County Arpt.)	C
PU	Pueblo, Colo. (mun. arpt.)	C
PW	Portland, Maine (mun. arpt.)	C
PX	Pierre, S. Dak. (mun. arpt)	C
PY	Potrero Hill, Calif	C
QA	Muskoka, Ont	CAN
QB	Quebec, P. Q	CAN
QC	Stirling, Ont	CAN
QD	Dease Lake, B. C	CAN
QE	Kimberly, B. C	CAN
QF	Penhold, Alta	CAN
QG	Windsor, Ont	CAN
QH	Watson Lake, B. C	CAN
QI	Glencoe, Ont	CAN
QJ	Porquis Jct., Ont	CAN
QK	Kenora, Ont	CAN
QL	Lethbridge, Alta	CAN
QM	Moncton, N. B	CAN
QN	Nakina, Ont	CAN
QO		
QP	Princeton, B. C	CAN
QQ	Selkirk, Yukon	CAN
QR	Regina, Sask	CAN
QS	Crescent Valley, B. C	CAN
QT	Port Arthur, (Fort Williams) Ont	CAN
QU	Grande Prairie, Alta	CAN
QV	Slave Lake, Alta	CAN
QW	Battleford, Sask	CAN
QX		
QY		
QZ	Jarvis, Ont	CAN
RA	Raleigh, N. C. (mun. arpt.)	C
RC	Rochester, N. Y. (mun. arpt.)	C
RD	Rockford, Ill. (McChesney Arpt.)	C
RE	Rio Hata, Panama	W
RF	Cove Valley, Pa	C
RH	Rodeo, N. Mex	C
RK	Bismarck, N. Dak	C
RL	Silver Lake, Calif	C
RN	Akron, Colo	C
RO	Roanoke, Va. (mun. arpt.)	C
RP	Reno, Nev. (United Arpt.)	C
RQ	Randolph Field, Tex., San Antonio, Tex	W
RR	Rochester, Minn	C
RS	Umnak Island, Alaska	C
RT	Rock Springs, Wyo. (mun. arpt.)	C
RU	Reeves Field (San Pedro, Calif.), Roosevelt Air Base	N
RV	Riverside, Calif	C
RW	Richmond, Va. (Richard E. Byrd Arpt.)	C
RX	Ruby, Alaska	C
RY		
RZ	Rapid City, S. Dak. (mun. arpt.)	C
SA	Seattle, Wash. (Boeing Field)	C
SB	South Boston, Va	C
SC	Mt. Shasta, Calif	C
SD	Sidney, Nebr	C
SF	San Francisco, Calif. (mun. arpt.)	A

Identification	Station	
SG	San Antonio, Tex. (portable)	C
SH	Savannah, Ga. (Hunter Field)	C
SI	Saginaw, Mich. (mun. arpt.)	A
SJ	Sitka, Alaska (W. B. office)	D
SL	Salt Lake City, Utah (mun. arpt.)	C
SM	Spokane, Wash. (Felts Field)	C
SN	South Bend, Ind. (Bendix-St. Joseph County Arpt.)	C
SO	Smiths Grove, Ky	C
SP	Superior, Mont	C
SQ	San Diego, Calif. (Lindbergh Field)	C
SR	Syracuse, N. Y. (mun. arpt.)	C
ST	New Florence, Mo	C
SU	Spartanburg, S. C. (Spartanburg Memorial Arpt.)	C
SV	Sunbury, Pa	A
SW	Moffett Field (Near Mountain View, Sunnyvale, Calif.)	W
SY	Dutch Harbor, Alaska	C
SZ	Sacramento, Calif. (mun. arpt.)	C
TA	McChord Field, Tacoma, Wash	W
TC	Tucumcari, N. Mex	C
TD	Trinidad, Colo	C
TF	Scottsbluff, Nebr	C
TG	Traverse City, Mich	C
TH	Terre Haute, Ind. (Paul Cox Arpt.)	C
TJ	Tallahassee, Fla. (Dale Mabry Field)	C
TL	Toledo, Ohio (mun. arpt.)	C
TM	Tampa, Fla. (Peter O. Knight Arpt.)	C
TP	Easton, Wash	C
TR	Texarkana, Ark. (mun. arpt.)	C
TS	Tulsa, Okla. (mun. arpt.)	C
TT	King City, Calif	A
TV	Tyler, Texas (mun. arpt.)	C
TW	Tanana Crossing, Alaska	C
TX	Tintic, Utah	C
TY	Tylertown, Miss	C
TZ	Tucson, Ariz. (mun. arpt.)	C
UA	Utica, N. Y. (mun. arpt.)	C
UB	Bethel, Alaska	C
UC	Muroc, Calif	W
UD	Howland Island (PAC)	C
UF	Hilo, Hawaii, T. H	C
UH	Plymouth, Utah	C
UI	Minot, N. Dak	C
UJ	Petersburg, Alaska	C
UK	Muskegon, Mich. (County Arpt.)	C
UL	Montreal, P. Q	CAN
UM	Meridian, Miss. (Key Field)	C
UN	Macon, Ga. (Herbert Smart Field)	C
UO	Monroe, La. (Selman Field)	C
UQ	Columbiaville, N. Y	C
UR	Manchester, N. H. (mun. arpt.)	W
US	Pulaski, Va	C
UU	Valdosta, Ga	W
UV	Barre-Montpelier, Vt. (mun. arpt.)	C
UX	Palacios, Tex	C
VC	Sault Ste. Marie, Mich. (mun. arpt.)	C
VD	Augusta, Ga. (Daniel Field)	C
VE	Lively, Va	C
VF	Victoria, Tex	W
VH	Las Vegas, N. Mex. (mun. arpt.)	C
VI	Victoria, B. C	CAN
VJ	Unalaska, Alaska	C
VK	Vickery, Ohio	C
VL	Lawson Field, Ft. Benning, Ga	W
VM	Gage, Okla	C
VN	Haines, Alaska	C
VO	Connellsville, Pa	W

Identification	Station	
VP	Sand Island, Honolulu, T. H	W
VQ	Homer, Alaska	C
VR	Vancouver, B. C	CAN
VT	MacDill Field, Tampa, Fla	W
VU	Windsor Locks, Conn	W
VX	Ventosa, Nev	C
VY	Yakutat, Alaska	C
VZ	Delta, Utah	C
WA	Washington, D. C. (National Arpt.)	C
WB	Aniak, Alaska	C
WC	Waco, Tex. (Rich Field)	C
WD	Wichita, Kans. (mun. arpt.)	C
WE	Warren, Ohio	C
WF	Wichita Falls, Tex. (Kell Field)	C
WG	Winnipeg, Man	CAN
WH	McGrath, Alaska	C
WI	Wilkes-Barre, Pa. (mun. arpt.)	C
WJ	Westfield, Mass. (Barnes Arpt.)	C
WK	Woodward, Pa	C
WL	Walla Walla, Wash	C
WM	Mitchel Field, L. I., N. Y	W
WO	Winslow, Ariz. (T & W Af Arpt.)	C
WP	Wink, Tex	C
WQ	Wamsutter, Wyo	C
WR	Warsaw, Ky	C
WS	Williams, Calif	C
WU	Watertown, S. Dak. (mun. arpt.)	C
WV	Wendover, Utah	C
WW	Whitehall, Mont	C
XA	Allentown, Pa	C
XB	Broadview, Sask	CAN
XC	Cranbrook, B. C	CAN
XD	Edmonton, Alta	CAN
XE	Saskatoon, Sask	CAN
XF	Dartmouth, N. S	CAN
XG	Megantic, P. Q	CAN
XH	Medicine Hat, Alta	CAN
XI	Killaloe, Ont	CAN
XJ	Fort St. John, B. C	CAN

Identification	Station	
XK	Pagwa, Ont	CAN
XL	Sioux Lookout, Ont	CAN
XM	Smithville, Tenn	C
XN	Austin, Tex. (Robert Mueller Arpt.)	C
XO	Carmi, B. C	CAN
XP	Parco, Wyo	C
XQ	Nelson, B. C	CAN
XR	Earlton Junction, Ont	CAN
XS	Prince George, B. C	CAN
XT	Atlantic City, N. J	A
XU	London, Ont	CAN
XV	Gulkana, Alaska	C
XW	Maxwell Field, Montgomery, Ala	W
XY	White Horse, Yukon	CAN
XZ	McMurray, Alta	CAN
YA	Yakima, Wash	C
YB	North Bay, Ont	CAN
YC	Calgary, Alta	CAN
YD	Smithers, B. C	CAN
YE	Fort Nelson, B. C	CAN
YF	Penticton, B. C	CAN
YG	Charlottetown, P. E. I	CAN
YH	Blythe, Calif	C
YI	Rivers, Man	CAN
YJ	Sidney Is., B. C	CAN
YK	Yoakum, Tex	C
YL	Sioux Falls, S. Dak. (mun. arpt.)	C
YM	Cowley, Alta	CAN
YN	Swift Current, Sask	CAN
YO	Nome, Alaska	C
YQ	Ft. Graham, B. C	CAN
YR	Peace River, Alta	CAN
YS	Blissville, N. B	CAN
YT	Sorel, P. Q	CAN
YU	Kapuskasing, Ont	CAN
YV	Archbold, Ohio	C
YW	Armstrong, Ont	CAN
YX	Sioux City, Iowa (mun. arpt.)	C
YY	Sault Ste. Marie, Ont	CAN
YZ	Malton, Ont	CAN
ZA	Santo, Tex	C
ZD	Springfield, Ill. (mun. arpt.)	C
ZE	Ogden, Utah	W

Identification	Station	
ZF	Springfield, Mo. (mun. arpt.)	C
ZG	Port Heiden, Alaska	C
ZH	Shreveport, La. (mun. arpt.)	C
ZJ	St. Joseph, Mo. (Rosecrans Field)	C
ZN	San Antonio, Tex. (Stinson Field)	C
ZQ	Presque Isle, Maine	W
ZS	Salinas, Calif. (mun. arpt.)	C
ZT	Strevell, Idaho	C
ZV	Springfield, Mass	D
ZX	Sexton Summit, Oreg. (mun. arpt.)	C
ZY	Sheridan, Wyo. (mun. arpt.)	C
ZZ	Yakataga, Alaska	C
CAG	Atlanta, Ga	ATC
CBU	Los Angeles, Calif	ATC
CCC	Cincinnati, Ohio	ATC
CCG	Chicago, Ill	ATC
CCV	Cleveland, Ohio	ATC
CDT	Detroit, Mich	ATC
CFV	Fort Worth, Tex	ATC
CLS	St. Louis, Mo	ATC
CNY	New York, N. Y	ATC
COA	Oakland, Calif	ATC
CPT	Pittsburgh, Pa	ATC
CSA	Seattle, Wash	ATC
CSL	Salt Lake City, Utah	ATC
CWA	Washington, D. C	ATC
FAA	Ann Arbor Mich. (mun. arpt.)	
FAD	Advance, Ind	*
FAF	Arcola, Tex	*
FAI	Ashburn, Ill	
FAL	Angola, N. Y	*
FAM	Albertson, Mont	*
FAZ	Allanreed, Tex	
FBA	Banning, Calif	*
FBD	Pittsburgh, Pa. (Bettis Field)	
FBG	Bangor, Mich	*
FBH	Benton Harbor, Mich	
FBN	Belen, N. Mex	*
FBO	Bowie, Md	*
FBP	Bay Point, Calif	*

Identification	Station	
FBR	Brighton, Ohio	*
FBS	Bessie, Okla	
FBT	Butler, Pa	
FBV	Branchville, N. Y	
FBX	Bendix, N. J	
FCA	Coalville, Utah	*
FCB	Lake Carey, Pa	
FCC	Central City, Ill	
FCF	Clifton, Tex	
FCG	Cedar Grove, Ind	*
FCH	Cabbage Hill, Oreg	*
FCI	California, Iowa	*
FCK	Crooked Creek, Pa	
FCL	Carlisle, Pa	*
FCN	Carlin, Nev	*
FCP	College Park, Md	
FCR	Coldwater, Miss	*
FCS	Classon Point, N. Y	
FCU	Cuba, Tenn	*
FCX	Corfu, N. Y	
FCY	Crystal City, Mo	
FDA	Downey, Calif. (Vultee Arpt.)	
FDC	Dacono, Colo	*
FDD	Dover, Del	
FDO	Delano, Calif	
FDP	Du Page, Ill	
FDS	De Soto, Kans	*
FDV	Denver, Colo. (Walter Higgley Arpt.)	
FDW	Dungeness, Wash	*
FEG	Egbert, Wyo	*
FEP	East Pembroke, N. Y	*
FES	Excelsior Springs, Mo	*
FET	Etter, Minn	*
FEY	Elyria, Ohio	
FFN	Fontana, Calif	*
FFR	Forked River, N. J	
FFT	Forney, Tex	*
FFV	Fisherville, Tenn	*
FFW	Fairview, Tenn	*
FGA	Genesee, Wis	*
FGC	Grove City, Pa	
FGD	North Springfield, Pa	*
FGF	Greenfield, Ind	*
FGG	Golden Gate Bridge, Calif	
FGL	Gilroy, Calif	
FGP	Guadalupe Pass, Tex	*
FGS	Greencastle, Ind	*

Identification	Station	
FGV	Greenville, Ill	
FGW	Spokane, Wash. (Geiger Field)	
FHA	Highland, Ill	
FHC	Hicksville, Ohio	
FHG	Hughes, Ark	*
FHI	Hancock, Iowa	*
FHK	Hookstown, Pa	*
FHL	Hamel, Minn	*
FHM	Hueco Mt., Tex	*
FHN	Herndon, Va	*
FHO	Homerville, Ohio	*
FHP	Highland Park, Ill	
FHT	Hobart, Wash	*
FHU	Huntington, Vt	*
FHR	Harrington Ranch, Tex	*
FHS	Humeston, Iowa	
FHV	Hybla Valley, Va	
FHW	Hawkins, Tex	
FHY	Hickory, Pa	*
FID	Indianapolis, Ind. (Hoosier Arpt.)	
FIJ	Imperial Beach, Calif	*
FJO	Jordan, Minn	*
FJS	Justin, Tex	
FJT	Joshua, Tex	*
FJV	Jerseyville, Ill	
FKE	Kingsville, Tex	
FKT	Kenton, Ohio	
FKW	Kenosha, Wis	*
FLB	Latrobe, Pa	
FLC	Lebec, Calif	*
FLD	Long Grove, Ill	
FLE	Lebanon, N. J	*
FLF	Mt. Leonard, Mo	*
FLH	La Habra, Calif	*
FLI	Coney Is., N. Y	
FLN	Layton, Utah	*
FLO	Lowell, Ind	*
FLQ	Laquey, Mo	
FLR	Luray, Mo	
FLS	Lansing, Ill	
FLT	Lasoya, Tex	*
FLV	Locust Grove, Ga	*
FLX	Luxora, Ark	
FMA	Media, Pa	*
FMB	Mesa, Ariz	*
FMC	Michigan City, Ind	
FMD	McDonald, Mont	*
FME	Mt. Eden, Calif	
FMF	Marietta, Okla	*
FMG	Madras, Ga	*
FMH	Union, Mich	
FMI	Monee, Ill	
FMJ	Morris Plains, N. J	*
FML	Mt. Liberty, Ohio	*
FMM	Millis, Mass	*
FMN	Metuchen, N. J	
FMO	Mt. Orab, Ohio	*
FMP	Mount Prospect, Ill	*
FMQ	Montpelier, Ohio	
FMR	Murfreesboro, Tenn	*
FMS	Mason Springs, Md	*
FMT	Mottville, Mich	
FMU	Mount Union, Pa	
FMV	Morrisville, Pa	*
FMW	Moscow, Mich	
FNA	New Alexandria, Pa	*
FNB	New Brunswick, N. J	*
FNC	New Carlisle, Ind	
FND	Newalla, Okla	
FNG	Norman, Okla	
FNH	Newhall Pass, Calif	*
FNK	Newark, Ill	*
FNL	North Liberty, Ind	
FNM	North Beverly, Mass	*
FNO	Newark, Ohio	*
FNP	Mineola, Mo	
FOE	Olathe, Kans	
FOF	Oxford, Kans	*
FOL	Oil City, Pa	
FON	Ocean City, Md	
FPB	Plattsburg, Mo	
FPC	Port Chester, N. Y	*
FPD	Parkland, Wash	*
FPE	Peoga, Ind	*
FPG	Portage, Pa	
FPH	Stephentown, N. Y	*
FPL	Platte City, Mo	*
FPM	Palma, N. Mex	
FPN	Parkman, Ohio	
FPR	Port Royal, Va	
FPS	St. Peters, Mo	
FPT	Pittsburg, Ill	
FPV	Perryville, Ariz	
FRB	Rockaway Beach, N. Y	
FRL	Dearborn, Mich. (Ford Arpt.)	

Identification	Station	
FRN	Rensselaer, Ind	
FRR	Red Rock, Ariz	*
FRU	Riverton, Utah	*
FRV	Ravenswood, W. Va	
FSA	Saline, Mich	*
FSC	Scottdale, Pa	*
FSE	Spangle, Wash	*
FSG	Stone Mt., Ga	*
FSH	Sheridan, Ill	
FSI	St. George, Ill	
FSK	Skiatook, Okla	
FSL	Seligman, Ariz	
FSM	Sandia Mt., N. Mex	*
FSN	Slatington, Pa	*
FSO	Sikeston, Mo	
FSP	Secret Peak, Nev	*
FSR	Smyrna, Ga	*
FSS	San Simeon, Calif	
FST	Stamford, Conn	
FSU	Summerhill, Pa	*
FSV	Silver Crown, Wyo	*
FTH	Thornton, Ill	
FTJ	Tejon, Calif	
FTC	Tracy, Calif	
FTL	Trail, Oreg	*
FTM	Timpie, Utah	*
FTP	Topeka, Ind	
FTR	Two Rivers, Wyo	
FTS	Mt. Tanalpais, Calif	
FTW	Tewksbury, Mass	*
FTY	Troy, Ohio	
FUA	Hershey, Nebr.	
FUB	Hinckley, Ill.	
FUD	Normandy, Ill	
FUF	Watkins, Colo	*
FUH	Hancock, Nebr	*
FUJ	Norristown, Pa	
FUO	Union, Ky	*
FVC	Visalia, Calif	
FVL	Vail, Ariz	*
FVM	Vermillion, Ohio	*
FVN	Vincennes, Ind	
FVY	Van Nuys, Calif. (Metropolitan Arpt.)	
FWA	Washougal, Wash	*
FWB	Willoughby, Ohio	
FWC	Washburn, Tex	
FWD	Williamette, Oreg	*
FWE	Weatherford, Tex	*

Identification	Station	
FWI	Wixom, Mich	*
FWL	Wingfoot Lake, Ohio	
FWM	Winston, Mont	*
FWN	Wadsworth, Nev	*
FWO	Wilmington, Ohio	*
FWP	Wills Point, Tex	
FWQ	Wilson, Ill	
FWR	Wood River, Ill	*
FWS	Whitetail, Mont	*
FWT	Wetmore, Tex	*
FWV	Westview, Ohio	
FWW	Woodland, Wash	*
FWX	Waxahachie, Tex	*
FWY	Watsonville, Calif	
FZE	San Jose, Calif	
GEH	Ediz Hook, Wash. (Port Angeles)	G
GNY	New York, N. Y. (Coast Guard Center)	G
HAA	Alatna, Alaska	D
HAB	Barrow, Alaska	D
HAC	Annex Creek, Alaska	D
HAD	Deering, Alaska	D
HAE	Craig, Alaska	D
HAF	Cape Spencer, Alaska	D
HAG	Gamble, Alaska	D
HAI	Hot Springs, Alaska	D
HAK	Kanatak, Alaska	D
HAM	Ambrose Lightship (off N. Y. C.)	D
HAO	Circle, Alaska	D
HAP	Portage, Alaska	D
HAQ	Cape Hinchinbrook, Alaska	D
HAR	Marias, Mex	D
HAT	Teller, Alaska	D
HAU	Unalakleet, Alaska	D
HAV	Savoonga, Alaska	D
HAW	Hawthorne, Nev	D
HAX	Paxson, Alaska	D
HAY	Hydaburg, Alaska	D
HAZ	Crooked Creek, Alaska	D
HBA	Alameda, Calif. (San Francisco Bay Airdrome)	D
HBE	Beeville, Tex	D
HBF	Blunts Reef Lightship (near Cape Mendocino, Calif.)	D
HBI	Block Island, R. I	D

Identification	Station	
HBJ	Burlington, Vt. (city office)	D
HBK	Brookings, Oreg	D
HBL	Burwell, Nebr	D
HBO	Bonners Ferry, Idaho	D
HBR	Brady, Tex	D
HBX	Buffalo Springs (Catalina I., Calif.)	D
HBY	Big Piney, Wyo	D
HCA	Canton, N. Y	D
HCD	Cape Decision, Alaska	D
HCG	Craig, Colo	D
HCJ	Coatzacolcos, Mex	D
HCK	Colebrook, B. C	D
HCL	Colville, Wash	D
HCM	Chetumal, Mex	D
HCN	Clinton, Mo	D
HCO	Cody, Wyo	D
HCP	Campeche, Mex	D
HCS	Coco Solo, C. Z	D
HCT	Coldwater, Ohio	D
HCX	Cokato, Minn	D
HCZ	Carrizozo, N. Mex	D
HDA	Sand Point, Alaska	D
HDB	Hooper Bay, Alaska	D
HDC	St. Michael, Alaska	D
HDD	Dillingham, Alaska	D
HDE	Stonyriver, Alaska	D
HDF	Little Port Walter, Alaska	D
HDG	Stevens, Alaska	D
HDH	Holy Cross, Alaska	D
HDI	Ophir, Alaska	D
HDJ	Broad Pass, Alaska	D
HDK	Canyon Creek, Alaska	D
HDL	Haycock, Alaska	D
HDM	Durnham, N. H	D
HDN	Napaimute, Alaska	D
HDO	Selawick, Alaska	D
HDP	Taylor, Alaska	D
HDQ	Point Hope, Alaska	D
HDR	Adrian, Tex	D
HDS	Point Lay, Alaska	D
HDT	Matanuska, Alaska	D
HDU	Beaver, Alaska	D
HDV	Attu, Alaska	D
HDW	Dawson, Minn	D
HDX	Nunivak, Alaska	D
HDY	Puntilla, Alaska	D
HDZ	Cantwell, Alaska	D
HEA	Cape St. Elias, Alaska	D
HEB	No Grub, Alaska	D
HEC	Curry, Alaska	D
HED	Council, Alaska	D
HEE	Livengood, Alaska	D
HEF	Soloman, Alaska	D
HEH	Hoonah, Alaska	D
HEI	King Island, Alaska	D
HEJ	Jackwade, Alaska	D
HEL	Eldred Rock, Alaska	D
HEM	Marshall, Alaska	D
HEN	Chicken, Alaska	D
HEO	Copper Center, Alaska	D
HEP	Pilot Point, Alaska	D
HES	Ellis, Kansas	D
HET	Tenakee, Alaska	D
HEU	Taku Lodge, Alaska	D
HEW	Wales, Alaska	D
HEX	Candle, Alaska	D
HEY	McKinley Park, Alaska	D
HEZ	Kotzebue, Alaska	D
HFA	Stampede, Alaska	D
HFC	Coal Creek, Alaska	D
HFD	Scotch Cap, Alaska	D
HFE	Seward, Alaska	D
HFF	Five Finger Light, Alaska	D
HFH	Circle Hot Springs, Alaska	D
HFI	Sentinal Island, Alaska	D
HFJ	Shungnak, Alaska	D
HFK	Klukwan, Alaska	D
HFL	Flat, Alaska	D
HFM	Mary Island, Alaska	D
HFN	Nenana, Alaska	D
HFQ	Sleitmute, Alaska	D
HFR	Radioville, Alaska	D
HFS	Safety, Alaska	D
HFT	Tree Point, Alaska	D
HFU	Richardson, Alaska	D
HFV	Shishmaref, Alaska	D
HFW	White Mountain, Alaska	D
HFX	Fairbanks, Alaska (W. B. office)	D
HFY	Pylgrim, Alaska	D
HFZ	Wiseman, Alaska	D
HGA	Akulurak, Alaska	D
HGC	Chitina, Alaska	D
HGF	Kasilof, Alaska	D
HGI	Guard Island, Alaska	D
HGJ	Guadalajara, Mex	D
HGK	Kaltag, Alaska	D

Identification	Station	
HGL	Golovin, Alaska	D
HGN	La Grange, Ga	D
HGP	Good Paster, Alaska	D
HGS	Skagway, Alaska	D
HGT	Tanalian Point, Alaska	D
HGV	Grangeville, Idaho	D
HGY	Tyonek, Alaska	D
HGZ	Tetlin, Alaska	D
HHN	Houghton, Mich	D
HHO	Houghton Lake, Mich	D
HHQ	Anchorage, Alaska (W. B. office)	D
HHR	Hood River, Oreg	D
HHS	Hermosillo, Mex	D
HHU	Hughes, Alaska	D
HHY	Healy, Alaska	D
HIN	Independence, Calif	D
HJA	Central, Alaska	D
HJB	Hog River, Alaska	D
HJC	Rainbow, Alaska	D
HJE	Juneau, Alaska (W. B. office)	D
HKC	Kimshan Cove, Alaska	D
HKG	Ketchikan, Alaska (W. B. office)	D
HKN	Angoon, Alaska	D
HLC	La Crosse, Wash	D
HLH	Laupahoehoe, Hawaii	D
HLI	Island of Lanai, Hawaii	D
HLK	Haleakala, Hawaii	D
HLN	Lebanon, N. H	D
HLP	La Paz, Mex	D
HMC	Minchumina, Alaska	D
HMF	Morse Field, Hawaii	D
HMM	Mount Mitchell, N. C	D
HMN	Managua, Nicaragua	D
HMO	Hickam Field, Oahu, T. H	D
HMP	Moclips, Wash	D
HMQ	Mogollon, N. Mex	D
HMR	Morelia, Mex	D
HMU	Monument, Colo	D
HMV	Monroeville, Ala	D
HMW	Mt. Washington, N. H	D
HMY	Mt. Ayr, Iowa	D
HMZ	Monticello, Ark	D
HNC	Newcastle, Wyo	D
HNK	Kukuihaele, Hawaii	D
HNU	Nulato, Alaska	D
HNV	Newport, Vt	D
HNW	Wheeler Field, Oahu, T. H	D
HNY	New York, N. Y. (city office, W. B.)	D
HOB	Obregon, Oreg	D
HOL	Haycock, Alaska	D
HOM	Homestead, Molakai	D
HOR	Oroville, Wash	D
HOX	Oaxaca, Mex	D
HOZ	Lihue, Kauai	D
HPA	Point Arguello, Calif	D
HPB	Point Piedras Blancas, Calif	D
HPD	Portland, Maine (city office)	D
HPF	Park Falls, Wis	D
HPG	Petersburg, W. Va	D
HPH	Point Hueneme, Calif	D
HPI	Pikeville, Ky	D
HPM	Point Montara, Calif	D
HPO	Point Arena, Calif	D
HPS	Paris, Tenn	D
HPY	Point Reyes, Calif	D
HRB	Harbor Beach, Mich	D
HRU	Rumford, Maine	D
HSA	Salisbury, Md	D
HSF	San Francisco, Calif. (city office)	D
HSJ	San Juan, P. R	D
HSM	Salmon, Idaho	D
HSN	San Nicolas Island (coast of Calif.)	D
HSP	Spencer, Iowa	D
HST	Stearns, Ky	D
HSU	Susanville, Calif	D
HTB	Cartago, Colombia	D
HTC	Cucuta, Colombia	D
HTD	Chafurro, Colombia	D
HTE	Iprates, Colombia	D
HTF	Taft, Calif	D
HTG	Medellin, Colombia	D
HTH	Otu, Colombia	D
HTI	Palanquero, Colombia	D
HTJ	Pato, Colombia	D
HTK	San Marco, Colombia	D
HTL	Tame, Colombia	D
HTM	Villavicencio, Colombia	D
HTN	Belem, Brazil	D
HTO	Townsend, Mont	D
HTP	Borinquen, P. R	D

Identification	Station		Identification	Station	
HTQ	Camocim, Brazil	D	HZI	San Jose, Costa Rica	D
HTR	Fortaleza, Brazil	D	HZJ	San Salvador, Salvador	D
HTS	Manuas, Brazil	D	HZK	Guatemala, Guatemala	D
HTT	Porto Velho, Brazil	D	HZL	Carmen, Mexico	D
HTU	Tupelo, Miss	D	HZM	Minititlan, Mexico	D
HTV	Santarem, Brazil	D	HZN	Tuxpem, Mexico	D
HTW	Sao Luiz, Brazil	D	HZO	Mexicali, Mexico	D
HTX	Tulancingo, Mex	D	HZS	Zacatecas Mexico	D
HUS	Americus, Ga	D			
HVA	Recife, Brazil	D	JBI	Belle Isle, Nfld	D
HVB	Balboa, C. Z	D	JBM	Hamilton, Bermuda	D
HVC	Cristobal, C. Z	D	JBO	Botwood, Nfld	D
HVD	Almirante, Panama	D	JCA	Cartwright, Lab	D
HVE	Port Limon, Costa Rica	D	JCC	Clarke City, Que	D
HVF	Tegucigalpa, Honduras	D	JCH	Chatham, N. B	D
HVG	San Julian, Cuba	D	JCR	Cape Race, Nfld	D
HVH	Camaguey, Cuba	D	JFA	Fame Point, Que	D
HVI	Antilla, Cuba	D	JFG	Fogo, Nfld	D
HVJ	Baracoa, Cuba	D	JFP	Father Point, Que	D
HVK	Santiago, Cuba	D	JFR	Fredericton, N. B	D
HVL	Port de France, Martinique	D	JGB	Grand Bank, Nfld	D
HVM	Port of Spain, Trinidad	D	JGR	Grindstone Is., Que	D
HVN	St. Johns, Antigua	D	JHA	Hope's Advance, Que	D
HVO	Georgetown, B. Guiana	D	JHR	Harrington, Que	D
HVP	Cienfuegos, Cuba	D	JJN	St. John's, Nfld	D
HVT	Paramaribo, D. Guiana	D	JKD	Kedgewick, N. B	D
HVS	San Pedro de Pacoris, Dom. Rep	D	JMI	Millertown, Nfld	D
HVU	Cayenne, F. Guiana	D	JNP	Newfoundland Airport, Nfld	D
HVV	Coro, Venezuela	D	JNW	North West River, Lab	D
HVW	Bogota, Colombia	D	JRE	Resolution, N. W. T	D
HVX	Buenaventura, Colombia	D	JSA	Sable Is., N. S	D
HVY	Cali, Colombia	D	JSG	St. Georges, Nfld	D
HVZ	Cartagena, Colombia	D	JSJ	St. John, N. B	D
HWA	Walsenburg, Colo	D	JSL	Sandgirt Lake, Lab	D
HWC	Wolf Creek, Oreg	D	JSP	St. Paul Is., N. S	D
HWI	Winchester, Ky	D	JSW	Anticosti, (S. W. Pt.) Quebec	D
HWP	West Plains, Mo	D			
HWS	Warm Springs, Mont	D	JSY	Sydney, N. S	D
HWU	Wausau, Wis	D	JYA	Yarmouth, N. S	D
HYO	Koyuk, Alaska	D			
HZA	La Guaira, Venezuela	D	KAB	Arctic Bay, N. W. T	D
HZB	Maracaibo, Venezuela	D	KCB	Lac Dore (Chibougamau) Quebec	D
HZC	Barranquilla, Colombia	D			
HZD	Turbo, Colombia	D	KCH	Churchill, Man	D
HZE	David, Panama	D	KCO	Cochrane, Ont	D
HZF	Tejeria, Mexico	D	KCS	Chesterfield, N. W. T	D
HZG	Caripeto, Venezuela	D	KDO	Dolbeau, Que	D
HZH	Barcelona, Venezuela	D	KDU	Doucet, Que	D

Identification	Station	
KGL	Gods Lake, Man	D
KHY	Haileybury, Ont	D
KKI	Kingston, Ont	D
KMO	Moosonee, Ont	D
KNO	Nottingham, N. W. T	D
KPH	Port Harrison, Que	D
KPL	Pickle Lake, Ont	D
KPS	Parry Sound, Ont	D
KRL	Red Lake, Ont	D
KSM	San Maur, Que	D
KSO	Southampton, Ont	D
KTR	Trenton, Ont	D
KWR	White River, Ont	D
LAB	Alert Bay, Vancouver Island, B. C	D
LAK	Aklavik, N. W. T	D
LAL	Alliford Bay, B. C	D
LAT	Atlin, B. C	D
LBA	Banff, Alta	D
LBB	Bella Bella, B. C	D
LBH	Bull Harbor, Vancouver Is., B. C	D
LBL	Beaver Lodge, Alta	D
LCH	Coal Harbour, B. C	D
LCL	Cape Lazo, Vancouver Is., B. C	D
LCO	Coppermine, N. W. T	D
LDA	Dawson, Yukon	D
LDT	Dead Tree Point (Queen Charlotte Island)	D
LES	Estevan, B. C	D
LFA	Fairview, Alta	D
LFL	Frances Lake, B. C	D
LHH	Hudson Hope, B. C	D
LHO	Hope, B. C	D
LJA	Jasper, Alta	D
LKA	Kamloops, B. C	D
LKQ	Kain's Island, B. C	D
LKR	Keg River, Alta	D
LLA	Langara, B. C	D
LMA	Mayo, Yukon	D
LMI	Minnedosa, Man	D
LMJ	Moose Jaw, Sask	D
LNH	Norway House, Man	D
LNO	Fort Norman, N. W. T	D
LOL	Oliver, B. C	D
LPA	Prince Albert, Sask	D

Identification	Station	
LPC	Pachena, Vancouver Island, B. C	D D
LPG	Prince George, B. C	D
LPR	Prince Rupert, B. C	D
LPS	Le Pas, Man	D
LQA	Qu'Appelle, Sask	D
LRO	Ross, N. W. T	D
LSI	Fort Simpson, N. W. T	D
LTI	Triple Island, B. C	D
LUT	Ucluelet, B. C	D
LWL	Williams Lake, B. C	D
NAG	Atlanta, Georgia (Camp Gordon)	N
NAL	Alameda, Calif. (Naval Air Station)	N
NAS	Anacostia, D. C. (Naval Station)	N
NBW	Squantum, Mass. (Naval Reserve Aviation Base)	N
NCH	Charleston, S. C. (Navy Yard)	N
NCG	Glenview, Ill. (Curtis-Reynolds)	N
NCL	Cape Lookout, N. C	N
NCR	Corpus Christi, Tex	N
NDA	Dahlgren, Va	N
NGI	Grosse Isle, Mich	N
NHA	Cape Hatteras, N. C	N
NHU	Pearl Harbor, T. H. (Naval Air Station)	N
NJX	Jacksonville, Fla. (Naval Air Base)	N
NNI	San Diego, Calif. (North Island Naval Air Station)	N
NOL	Miami, Fla. (Naval Res. Air Base)	N
NOU	Banana River, Fla	N
NPI	Parris Island, S. C. (Page Island)	N
NPN	Philadelphia, Pa	N
NQL	Biorka Island, Alaska	C
NQN	Quantico, Va. (Brown Field)	N
NQP	Quonset Point, R. I. (Naval Air Station)	N
NSC	San Clemente Is., Calif	N
NSF	Stinson Field, Wayne, Mich	N

Identification	Station	
NSJ	Japonski Island, (Sitka) Alaska	N
NSP	Sand Point, Seattle, Wash	N
NTP	Tongue Point, Oreg	N
PAC	Acapulco, Mexico	D
PAE	Alliance, Nebr	D
PAH	Athens, Tenn	D
PAK	Parks Airport, East St. Louis, Ill	D
PAL	Alexandria, La	D
PAM	Meachan, Oreg	D
PAP	Alpine, Tex	D
PAR	Arcadia, La	D
PAS	Lewiston, Maine	D
PAT	Atka, Alaska	D
PBA	Batesville, Ark	D
PBC	Baltimore, Md. (BOAC)	
PBD	Bend, Oreg	D
PBE	Boaz, Ala	D
PBF	Pine Bluff, Ark	D
PBG	Buffalo Gap, S. Dak	D
PBJ	Bemidji, Minn	D
PBK	East Waterford, Pa	D
PBM	Big Rapids, Mich	D
PBN	Bloomington, Ill	D
PBP	Batavia, N. Y	D
PBR	Blue Ridge, Ga	D
PBS	Burns, Oreg	D
PBT	Bridgeport, Conn	D
PBW	Brownwood, Tex	D
PBZ	Buffalo, Wyo	D
PCB	Chehalis, Wash	D
PCC	St. Petersburg, Fla	D
PCD	Carlsbad, N. Mex	D
PCE	Blairsville, Pa	D
PCF	Chipley, Fla	D
PCH	Calhan, Colo	D
PCI	Calais, Maine	D
PCK	Cape Sarichef, Alaska	D
PCL	Clayton, N. Mex	D
PCN	Canton, Pa	D
PCO	Coalinga, Calif	D
PCP	Crown Point, N. Mex	D
PCQ	Coatesville, Pa	D
PCR	Schenectady, N. Y	D
PCS	Columbus, Tex	D
PCV	Crewe, Va	D
PCW	Crawford, Nebr	D
PCX	Charlevoix, Mich	D
PCZ	Cozumel, Yucatan	D
PDF	Danforth, Maine	D
PDG	Durango, Colo	D
PDM	Des Moines, N. Mex	D
PDN	Duran, N. Mex	D
PDQ	Clarksburg, W. Va	D
PDR	Del Rio, Tex	D
PDV	Devils Lake, N. Dak	D
PDW	"Do Not Assign"	
PDX	Davenport, Iowa	D
PEA	Eastport, Maine	D
PEB	Sarasota, Fla	D
PED	Scranton, Pa	D
PEG	Eagle, Alaska	D
PEH	Nantucket, Mass	D
PEL	Ela, N. Carolina	D
PEM	Elizabeth City, N. C	D
PEO	Eldorado, Ark	D
PES	Estero, Calif	D
PEU	Eureka, Calif	D
PEV	Ely, Nev	D
PEX	Roosevelt Field, L. I., N. Y	D
PEY	Elk City, Okla	D
PFB	Fort Bragg, Calif	D
PFC	Ft. Collins, Colo	D
PFF	Flagstaff, Ariz	D
PFI	S. E. Farallon Island, Calif	D
PFK	Frankfort, Mich	D
PFL	Flat Top, W. Va	D
PFN	Fontana, Calif	D
PFR	Frostburg, Md	D
PGA	Garrison, N. Dak	D
PGC	Grand Canyon, Ariz	D
PGD	Geraldine, Mont	D
PGE	Gerona, Cuba	D
PGF	Geneseo Field, Kans	D
PGG	Pontiac, Mich	D
PGH	Guana Juato, Mex	D
PGI	Greenville, Maine	D
PGJ	Blanding, Utah	D
PGK	Goodland, Kans	D
PGL	Glasgow, Mont	D
PGM	Guantanamo, Cuba	D
PGN	Glendive, Mont	D
PGR	Green River, Utah	D
PGU	Guane, Cuba	D
PGV	Greenville, N. C	D

Identification	Station	
PGX	Guaymas, Mex	*D*
PGY	Greely, Colo	*D*
PGZ	Grand Coulee, Wash	*D*
PHA	Hatteras, N. C	*D*
PHB	Hobbs, N. Mex	*D*
PHD	Huntsville, Ohio	*D*
PHE	Avalon, Catalina, Calif	*D*
PHG	Hot Springs, N. C	*D*
PHJ	Wheatland, Wyo	*D*
PHK	Hinckley, Minn	*D*
PHL	Huntsville, Ala	*D*
PHO	Hollister, Calif	*D*
PHS	Santa Ana, Calif	*D*
PHT	Harrington, Wash	*D*
PHU	Kalamazoo, Mich	*D*
PHV	Havana, Cuba	*D*
PHY	Hyannis, Mass	*D*
PIA	Hickory, N. C	*D*
PID	Midwest, Wyo	*D*
PIF	Iowa Falls, Iowa	*D*
PIG	Big Timber, Mont	*D*
PIK	Inyokern, Calif	*D*
PIT	Ithaca, N. Y	*D*
PJA	Detour, Mich	*D*
PJB	Eagle Harbor, Mich	*D*
PJC	Grand Marias, Minn	*D*
PJD	Fort Gratiot, Mich	*D*
PJE	Isle Royale, Mich	*D*
PJF	Lansing Shoals, Mich	*D*
PJG	Judiths Gap, Mont	*D*
PJH	Mackinaw City, Mich	*D*
PJI	Manitou Isle, Mich	*D*
PJJ	Poes Reef, Cheboygan, Mich	*D*
PJK	Portage, Mich	*D*
PJL	Sturgeon Bay, Wis	*D*
PJM	South Manitou Is., Mich	*D*
PJN	Thunder Bay Island, Mich	*D*
PJO	Tawas Point, Mich	*D*
PJP	Whitefish Point, Mich	*D*
PJQ	St. Joseph, Mich	
PJR	Lorain, Ohio	*D*
PJS	Bois Blanc Island, Detroit River, Mich	*D*
PJT	Port Huron, Mich	*D*
PJU	Marysville, Mich	*D*
PJV	St. Clair Flats, Mich	*D*
PJW	Belle Isle (Coast Guard Station), Detroit, Mich	*D*
PJX	Detroit River Lighthouse, Detroit, Mich	*D*
PKA	Kalispell, Mont	*D*
PKD	Kellogg, Idaho	*D*
PKE	Keokuk, Iowa	*D*
PKG	Kanaga, Alaska	*D*
PKI	Cairo, Ill	*D*
PKK	Kalskag, Alaska	*D*
PKL	Kernville, Calif	*D*
PKN	Knapp Creek, N. Y	*D*
PKP	Kane, Pa	*D*
PKO	Knolls, Utah	*D*
PKR	Keyser Ridge, Md	*D*
PKX	Stockton, Utah	*D*
PLA	Lamar, Colo	*D*
PLB	Lufkin, Tex	*D*
PLC	Leadville, Colo	*D*
PLD	Lander, Wyo	*D*
PLE	Lexington, Ky	*D*
PLF	Patterson, La	*D*
PLI	Lincoln, Maine	*D*
PLK	Lake Placid, N. Y	*D*
PLM	Lemmon, S. Dak	*D*
PLN	Logan, W. Va	*D*
PLO	Laredo, Tex	*D*
PLQ	Lavina, Mont	*D*
PLR	Boswell, Pa	*D*
PLS	Larkspur, Colo	*D*
PLV	Linda Vista, Calif	*D*
PLW	Delaware Breakwater, Del	*D*
PLX	Los Angeles, Calif. (City Office, W. B.)	*D*
PLY	Lerdo, Mexico	
PMA	Modena, Utah	*D*
PMB	Morgantown, W. Va	*D*
PMD	Mt. Laguna, Calif	*D*
PME	Milesville, S. Dak	*D*
PMH	Mount Hamilton, Calif	*D*
PMJ	Maljamar, N. Mex	*D*
PML	McAlester, Okla	*D*
PMN	Alvin, Colo	*D*
PMO	Mankato, Minn	*D*
PMP	Mobridge, S. Dak	*D*
PMR	Mountainair, N. Mex	*D*
PMS	Miller, S. D	*D*
PMT	Milwaukee Air Terminal, Wis	*D*
PMV	Monte Vista, Colo	*D*
PMW	Mt. Wilson, Calif	*D*

Identification	Station	
PNA	Waterville, Maine	D
PNB	New Bedford, Mass	D
PNC	Provincetown, Mass	D
PNF	Northfield, Vt	D
PNH	Northhead, Wash	D
PNP	Newport, Oreg	D
PNR	Gardner, Kans	D
PNS	Norris Arm, Nfld	D
PNU	Nassau, B. W. I	D
PNW	North Bend, Oreg	D
PNY	New York, N. Y. (Pan American Operations).	
POC	Ocala, Fla	D
POW	Oswego, N. Y	D
PPA	Boulder City, Nev	D
PPB	Pine Bluffs, Wyo	D
PPF	Point Fermin, Calif	D
PPH	Phillipsburg, Kans	D
PPJ	Pasadena, Calif	D
PPL	Apalachicola, Fla	D
PPM	Platinum, Alaska	D
PPN	Point No Point, Wash	D
PPO	Paxton Springs, N. Mex	D
PPP	St. Paul, Alaska	D
PPS	Portland, Oreg. (Swan Island Arpt.)	D
PPT	Pratt, Kans	D
PPW	Port Washington, L. I., N. Y. (PAA).	
PPZ	Pasco, Wash	D
PQH	Quanah, Tex	D
PQL	Culiacan, Mex	D
PQM	Snoqualamie Pass, Wash	D
PQY	Quincy, Ill	D
PRC	Ridgecrest, N. C	D
PRK	Rockport, Mass	D
PRL	Rawlins, Wyo	D
PRM	Richlands, Va	D
PRN	Reading, Pa	D
PRS	Rapids, Alaska	D
PRU	Prairie Du Rocher, Ill	D
PRV	Raymondville, Tex	D
PRW	Colorado Springs, Colo	D
PRX	Rowe, N. Mex	D
PSD	Snow Hill, Md	D
PSF	Stanford, Mont	D
PSH	Sandy Hook, N. J	D
PSK	Skwentna, Alaska	D
PSL	San Miguel Is., Calif	D
PSM	Springfield, Minn	D
PSN	Scranton, Pa. (downtown W. B.)	D
PSP	Springer, N. Mex	D
PSR	Seymour, Ind	D
PST	Sanderson, Tex	D
PSU	Winston-Salem, N. C	D
PSV	St. Thomas, Virgin Islands	D
PSW	Stampede Pass, Wash	D
PSX	St. Xavier, Mont	D
PTA	Tatoosh, Wash	D
PTB	Tacubaya, Mex	D
PTF	Tombstone, Ariz	D
PTH	Thomasville, Ga	D
PTJ	Troutdale, Oreg	D
PTK	Tampico, Mex	D
PTL	Tapachula, Mex	D
PTS	Mt. Tamalpais, Calif	D
PTU	Tonopah, Nev	D
PTW	Turks Island, W. I	D
PUR	Urbanna, Va	D
PUS	Austin, Nev	D
PUT	Rocky Mount, N. C	D
PUU	Chihuahua, Mex	D
PUY	Monterey, Calif	D
PVF	Pierces Ferry, Ariz	D
PVG	Villahermosa, Guatemala	D
PVO	Mt. Vernon, Wash	D
PVW	Lakeview, Oreg	D
PVZ	Vera Cruz, Mex	D
PWA	Washington, Ind	D
PWB	Wenatchee, Wash	D
PWE	Wheeling, W. Va	D
PWF	Whiteface Mountain, N. Y	D
PWG	Williamsburg, Ky	D
PWI	Fort Yukon, Alaska	D
PWJ	Springfield, Mass	D
PWL	Wrangell, Alaska	D
PWM	Wilmington, Calif	D
PWO	Manzanillo, Mexico	D
PWR	White Rock, Colo	D
PWS	Del Monte, Calif	D
PWT	Winton, N. C	D
PWY	Wytheville, Va	D
PXM	Merida, Mexico	D
PXN	Mazatlan, Mexico	D
PXO	Progresso, Mexico	D
PXR	Corinth, Miss	D

Identification	Station	
PXS	Matamoros, Mexico	D
PXX	Mexico City, Mexico	D
PXY	Monterey, Mexico	D
PYE	Yellowstone, Wyo	D
PYO	N. Y. University, Bronx, N. Y	D
PYU	Yuma, Ariz	D
PZB	North Bend, Wash	D
PZN	Simpson, D. M., N. W. T	D
PZS	Las Cruces, N. Mex	D
PZW	Gassaway, W. Va	D
PZZ	Salina Cruz, Mexico	D
SBR	Fort Brown, Brownsville, Tex	S
SCL	Fort Clark, Eagle Pass, Tex	S
SJR	Johnson's Ranch, Tex	S
SRG	Fort Ringgold, Rio Grande, Tex	S
SMC	Fort McIntosh, Near Corpus Christi, Tex	S
TAH	Asheville, N. C	A
TAI	Ashley, N. Dak	C
TAY	Anthony, Kans	C
TBM	Bear Mountain, N. Y	A
TBR	Transatlantic Receiving Station (Barnegat, N. J)	C
TBS	Brunswick, Ga. (Malcolm B. McKinnon Arpt.)	C
TCK	Cadillac, Mich	C
TCL	Coalville, Utah	A
TDD	Dodge City, Kans	A
TDF	Dubuque, Iowa	A
TDO	Detroit, Mich. (mun. arpt.)	A
TDU	Douglas, Ariz. (mun. arpt.)	A
TEC	Escanaba, Mich	A
TEG	Grand Junction, Colo	A
TEJ	Winnemucca, Nev	A
TEN	Evergreen, Ala	C
TES	East St. Louis, Ill	D
TEW	Cheboygan, Mich	A
TEY	Charles City, Iowa	A
TEZ	E. Liverpool, Ohio	A
TFD	Frederick, Md	C
TFG	Pittsfield, Mass	C
TFN	Flint, Mich. (Bishop Arpt.)	C
TFP	Fort Plain, N. Y	C
TFQ	Port Townsend, Wash	A

Identification	Station	
TFR	Lamoni, Iowa	C
TGB	Green Bay, Wis	A
TGN	Curwensville, Pa	C
TGP	Guadalupe Pass, Tex	D
TGQ	Glens Falls, N. Y. (mun. arpt.)	C
TGU	Gladwin, Mich	C
TGX	Glendale, Calif	D
THC	Chadron, Nebr	C
THE	Hadley Field, New Brunswick, N. J	D
THS	Fort Smith, Ark	A
THV	Havre, Mont	A
TJF	Findlay, Ohio	C
TJN	Jackson, Mich. (Reynolds Field)	C
TJZ	Pampa, Tex. (mun. arpt.)	A
TKK	Concordia, Kans	A
TKP	Crown Point, Oreg	A
TKU	Mt. Pocono, Pa	C
TKV	Coffeyville, Kans	C
TKY	Kylertown, Pa	A
TLL	Lakeland, Fla	A
TLX	Lane, S. C	C
TMB	Binghamton, N. Y. (Tri-City Arpt.)	C
TMG	Raton, N. Mex. (mun. arpt.)	C
TMH	Marshall, Mo	A
TMU	Montague, Calif	A
TNB	Malden, Mo	C
TNG	Anniston, Ala. (mun. arpt.)	C
TNM	Mason City, Iowa (mun. arpt.)	C
TNV	New Haven, Conn. (mun. arpt.)	A
TOI	Live Oak, Fla	A
TOS	Socorro, N. Mex	C
TOY	Olympia, Wash. (mun. arpt.)	A
TPC	Ponca City, Okla. (mun. arpt.)	C
TPJ	Pellston, Mich. (mun. arpt.)	C
TPL	Park Place, Pa	C
TPV	Paso Robles, Calif. (Paso Robles Field)	C
TPZ	Palestine, Tex	A
TRB	Roseburg, Oreg	A

Identification	Station	
TRG	Redding, Calif. (Benton Field)	A
TRI	Dansville, N. Y. (mun. arpt.)	C
TRJ	Rolla, Mo	C
TRM	Centerville, Ind. (Richmond Arpt.)	A
TSA	Transatlantic Transmitter Station (Sayville, N. Y.)	C
TSE	Spearfish, S. Dak. (Black Hills Arpt.)	C
TSK	Siskiyou Summit, Oreg	A
TSS	Story City, Iowa	C
TSX	Salem, Oreg. (Salem Arpt.)	A
TTB	Butler, Ga	C
TTE	Marquette, Mich	A
TTI	Williston, N. Dak	A
TTK	Tarkio, Mo	C
TTN	Trenton, N. J	A
TTO	Topeka, Kans	A
TTQ	Ticonderoga, N. Y	C
TTU	Tuscaloosa, Ala. (Hargrove Van De Graaf Field)	C
TUE	Prescott, Ariz	D
TUG	Montgomery, Ala. (Gunter Field)	A
TUP	Palm Springs, Calif	D
TUT	Beaumont, Calif	C
TUW	Cherry Fork, Ohio	C
TUZ	Underwood, N. Dak	D
TVA	Valentine, Nebr	A
TVB	Vero Beach, Fla. (mun. arpt.)	C
TVG	Parkersburg, W. Va	A
TVS	Vicksburg, Miss. (mun. arpt.)	C
TVV	Cut Bank, Mont	D
TVW	Coldwater, Mich	D
TWN	Warrenton, N. C	C
TWT	Waterman, Ill	A
TWC	Wilmington, N. C	A
TWY	Waynoka, Okla	A
TWZ	West Palm Beach, Fla. (Morrison Field)	C
TYP	Pensacola, Fla	D
TZB	Sandberg, Calif	A
TZC	St. Cloud, Minn	A
TZI	St. Ignace, Mich. (Mackinac Co. Arpt.)	C
TZK	Santa Fe, N. Mex. (mun. arpt.)	C
TZL	Lafayette, La. (mun. arpt.)	C
TZM	Santa Maria, Calif	D
TZO	Sulphur Springs, Tex	C
TZP	St. Paul, Minn. (mun. arpt.)	A
TZR	Santa Barbara, Calif. (mun. arpt.)	C
TZW	White River Junction, Vt. (Twin State Arpt.)	C
VXS	St. Hubert, P. Q	D
WAB	Aberdeen, Md. (Phillips Field)	W
WBC	Boston, Mass	W
WBD	Bakersfield, Calif. (Army Field #2)	W
WBF	Washington, D. C. (Bolling Field)	W
WBG	El Paso, Tex. (Biggs Field)	W
WBL	El Paso, Tex. (Fort Bliss)	W
WBN	Brownwood, Tex. (Camp Bowie)	W
WBR	San Antonio, Tex. (Brooks Field)	W
WCB	Essler Field, Alexandria, La	W
WCE	Camp Edwards, Mass	W
WCG	Chicago, Ill. (Army Reserve Base)	W
WCH	Miami, Fla. (Chapman Field)	W
WCI	Fort Jackson, S. C	W
WCN	Indianapolis, Ind. (Schoen Field, Fort Benj. Harrison)	W
WDF	San Antonio, Tex. (Duncan Field)	W
WEF	Valpariso, Fla. (Eglin Field)	W
WEG	Edgewood Arsenal, Md	W
WFC	Galveston, Tex. (Fort Crockett)	W
WFD	Fort Dix, N. J	W
WFI	Fishers Is., L. I., N. Y. (Fort Wright)	W
WFL	Tacoma, Wash. (Fort Lewis)	W

Identification	Station	
WFM	Atlanta, Ga. (Fort McPherson)	W
WFO	Chattanooga, Tenn. (Fort Oglethorpe)	W
WFW	Fort Wayne, Ind. (Baer Field)	W
WFX	Fairbanks, Alaska (Ladd Field)	W
WHT	Harlingen, Tex	W
WHQ	Anchorage, Alaska (Elmendorf Field)	W
WJC	Battle Creek, Mich. (Ft. Custer)	W
WKG	Annette Island, Alaska (Army Air Base)	W
WKX	Fort Knox, Ky	W
WLA	Los Angeles, Calif. (Nat. Guard, Griffith Park)	W
WLI	Little Rock, Ark. (Adams Field)	W
WLO	Lordsburg, N. Mex	W
WLS	St. Louis, Mo., Lambert Field (mun. arpt.)	W
WMA	Marfa, Tex	W
WMI	Madison, Ind. (Jefferson Proving Grounds)	W
WMM	Trenton, N. J. (Fort Monmouth)	W
WMT	Middletown, Pa. (Olmstead Field)	W
WMZ	March Field, Riverside, Calif	W
WNG	Philadelphia, Pa. (Pa. Nat. Guard)	W
WNK	Newark, N. J. (National Guard)	W
WOF	Omaha, Nebr. (Offutt Field, Ft. Cook)	W
WOR	Orlando, Fla	W
WPC	Pine Camp, N. Y. (Wheeler-Sack Field)	W
WPF	Pearson Field, Wash. (Vancouver)	W
WPI	Pittsburgh, Pa	W
WRF	Anniston, Ala. (Fort McClellan)	W
WRD	Kansas City, Kans. (Fairfax Field)	W
WSD	Sherman-Denison, Tex	W
WSF	Sumter, S. C. (Shaw Field)	W
WSH	San Antonio, Tex. (Fort Sam Houston)	W
WSM	Spokane, Wash. (Sunset Field)	W
WST	Indianapolis, Ind. (Stout Field)	W
WSZ	Sacramento, Calif. (Sacramento Air Depot McClellan Field)	W
WUX	Uniontown, Pa. (Burgess Field)	W
WVY	Yakutat, Alaska	W
WWF	Dayton, Ohio (Wright Field)	W
WWP	West Point, N. Y. (Stewart Field)	W
XKF	San Antonio, Tex. (Kelly Field)	WO
XLY	Hampton, Va. (Langley Field)	WO
XMT	Middletown, Pa. (Olmstead Field)	WO
XNU	Rantoul, Ill. (Chanute Field)	WO
XOP	Fayetteville, N. C. (Fort Bragg)	WO
XUG	Montgomery, Ala. (Gunter Field)	WO
XVL	Ft. Benning, Ga. (Lawson Field)	WO
XWM	Long Island, N.Y. (Mitchel Field)	WO
XXW	Montgomery, Ala. (Maxwell Field)	WO
YZO	Toronto, Ont	CAN
ZAB	Albuquerque, N. Mex	C
ZAG	Atlanta, Ga	C
ZBB	Bangor, Maine	C
ZBE	Boise, Idaho	C
ZCF	Charlotte, N. C	C
ZDT	Detroit, Mich. (Wayne County)	C
ZFB	Floyd Bennett Field, N. Y.	C
ZFT	Fresno, Calif	C

Identification	Station	
ZFW	Fort Wayne, Ind	C
ZHB	Long Beach, Calif	C
ZHJ	Houlton, Maine	C
ZJA	Jackson, Miss	C
ZJR	Baton Rouge, La	C
ZJX	Jacksonville, Fla	C
ZLA	Los Angeles, Calif. (Mines Field)	
ZLC	Lake Charles, La	C
ZLI	Little Rock, Ark	C
ZLQ	Las Vegas, Nev	C
ZLV	Louisville, Ky	C
ZMI	Everett, Wash	C
ZNA	Nashville, Tenn	C
ZNO	New Orleans, La	C
ZOL	Oklahoma City, Okla	C
ZON	Midland, Tex	C
ZOR	Orlando, Fla	C
ZPD	Portland, Oreg	C
ZPO	Pendleton, Oreg	C
ZSH	Savannah, Ga	C
ZSL	Salt Lake City, Utah	C
ZTJ	Tallahassee, Fla	C
ZTS	Tulsa, Okla	C
ZTZ	Tucson, Ariz	C
ZUM	Meridian, Miss	C
ZUR	Manchester, N. H	C
ZVD	Augusta, Ga	C
ZWF	Wichita Falls, Tex	C
ZWZ	West Palm Beach, Fla	C
ZZQ	Presque Isle, Maine	C
ZZS	Salinas, Calif	C

b. Alphabetically by station.

Station	Identification	
Aberdeen, Md. (Phillips Field)	W	WAB
Aberdeen, S. Dak. (mun. arpt.)	C	AN
Abilene, Tex. (mun. arpt.)	C	AP
Acapulco, Mex	D	PAC
Acomita, N. Mex	C	AK
Adairsville, Ga	C	AV
Adams Field, Little Rock, Ark	W	WLI
Advance, Ind	*	FAD
Advance, Mo	C	AF
Aklavik, N. W. T	D	LAK
Akron, Colo	C	RN
Akron, Ohio (mun. arpt.)	C	AX
Akulurak, Alaska	D	HGA
Alameda, Calif. (Naval Air Station)	N	NAL
Alameda, Calif. (San Francisco Bay Airdrome)	D	HBA
Alatna, Alaska	D	HAA
Albany, N. Y. (mun. arpt.)	C	AZ
Albany, Ga. (mun. arpt.)	C	GY
Albertson, Mont	*	FAM
Albuquerque, N. Mex. (mun. arpt.)	C	AB
Albuquerque, N. Mex	C	ZAB
Alert Bay, Vancouver Is., B. C	D	LAB
Alexandria, La	D	PAL
Alexandria, La. (Essler Field)	W	WCB
Alexandria, Minn	C	AE
Allanreed, Tex		FAZ
Allegheny County Arpt. (*See* Pittsburgh.)		
Allentown, Pa. (Allentown-Bethlehem Arpt.)	C	XA
Alliance, Nebr	D	PAE
Alliford Bay, B. C	D	LAL
Alma, Ga	C	AJ
Almirante, Panama	D	HVD
Alpena, Mich	C	AA
Alvin, Colo	D	PMN
Amarillo, Tex. (English Field)	C	AQ
Ambrose Lightship (off NYC)	D	HAM
Americus, Ga	D	HUS
Anacostia, D. C. (Naval Air Station)	N	NAS
Anchorage, Alaska (Elmendorf Field)	W	WHQ
Anchorage, Alaska (Merrill Field)	C	HQ
Anchorage, Alaska (W. B. Office)	D	HHQ
Anderson, S. C. (mun. arpt.)	C	AS

Station		Identification
Angola, N. Y	*	FAL
Angoon, Alaska	D	HKN
Aniak, Alaska	C	WB
Ann Arbor, Mich. (mun. arpt.)		FAA
Annette Island, Alaska (Army Air Base)	W	WKG
Annex Creek, Alaska	D	HAC
Anniston, Ala. (mun. arpt.)	C	TNG
Anthony, Kans	C	TAY
Anticosti, S. W. Pnt., Quebec	D	JSW
Antilla, Cuba	D	HVI
Anton Chico, N. Mex	C	AC
Any or all Communications Stations		CQ
Apalachicola, Fla	D	PPL
Arcadia, La	D	PAR
Archbold, Ohio	C	YV
Arcola, Tex	*	FAF
Arctic Bay, N. W. T	D	KAB
Ardmore, Okla	C	AT
Arlington, Oreg	D	AL
Armstrong, Ont	CAN	YW
Ashburn, Ill		FAI
Asheville, N. C	A	TAH
Ashfork, Ariz	C	FK
Ashley, N. Dak	C	TAI
Athens, Tenn	D	PAH
Atka, Alaska	D	PAT
Atlanta, Ga. (mun. arpt.)	C	AG
Atlanta, Ga	ATC	CAG
Atlanta, Ga. (Camp Gordon)	N	NAG
Atlanta, Ga	C	ZAG
Atlantic, Iowa	C	IZ
Atlantic City, N. J	A	XT
Atlin, B. C	D	LAT
Attu, Alaska	D	HDV
Auburn, Calif	C	AR
Augusta, Ga	C	VD
Augusta, Ga	C	ZVD
Augusta, Maine (State arpt.)	C	AW
Austin, Nev	D	PUS
Austin, Tex. (Robert Mueller Arpt.)	C	XN
Avalon, Catalina, Calif	D	PHE
Baker, Oreg	C	BK
Bakersfield, Calif. (Kern County Arpt.)	C	BD
Bakersfield, Calif. (Army Field No. 2)	W	WBD
Balboa, C. Z	----	HVB
Baltimore, Md. (BOAC)	----	PBC
Baltimore, Md. (Logan Field)	C	BO
Banana River, Fla. (via OU)	N	NOU
Banff, Alta	D	LBA
Bangor, Mich	*	FBG
Bangor, Maine (mun. arpt.)	C	BB
Bangor, Maine	C	ZBB
Banning, Calif	*	FBA
Baracoa, Cuba	----	HVJ
Barcelona, Venezuela	----	HZH
Barksdale Field, Shreveport, La	W	BY
Barranquilla, Colombia	----	HZC
Barre-Montpelier, Vt. (mun. arpt.)	C	UV
Barrow, Alaska	D	HAB
Batavia, N. Y	D	PBP
Bates Field, Ala. (*See* Mobile.)		
Batesville, Ark	D	PBA
Baton Rouge, La. (East Baton Rouge Parish Arpt.)	C	JR
Baton Rouge, La	C	ZJR
Battle Creek, Mich. (Kellogg Arpt.)	C	JC
Battleford, Sask	CAN	QW
Bay Point, Calif	*	FBP
Bear Mountain, N. Y	A	TBM
Beaumont, Calif	A	TUT
Beaumont, Tex. (mun. arpt.)	C	JU
Beaver, Alaska	D	HDU
Beaver Lodge, Alta	D	LBL
Beeville, Tex	D	HBE
Belem, Brazil	----	HTN
Belen, N. Mex	*	FBN
Belgrade, Mont	C	BL
Bella Bella, B. C	D	LBB

Station		Identification
Bellefonte, Pa	*C*	BF
Belleville, Ill. (Scott Field Army Arpt.)	*W*	CD
Belle Isle, Nfld	*D*	JBI
Belle Isle (Coast Guard Station), Detroit, Mich.	*D*	PJW
Bellingham, Wash. (Whatcom County Arpt.)	*C*	JJ
Bemidji, Minn	*D*	PBJ
Bend, Oreg	*D*	PBD
Bendix Field, Ind	----	FBX
Benton Field, Calif. (*See* Redding.)		
Benton Harbor, Mich	----	FBH
Beowawe, Nev	*C*	BA
Bessie, Okla	----	FBS
Bethel, Alaska	*C*	UB
Big Delta, Alaska	*C*	JQ
Big Piney, Wyo	*D*	HBY
Big Rapids, Mich	*D*	PBM
Big Springs, Nebr	*C*	BG
Big Spring, Tex. (mun. arpt.)	*C*	BZ
Big Timber, Mont	*D*	PIG
Biggs Field, El Paso, Tex.	*W*	WBG
Billings, Mont	*C*	BI
Biloxi, Miss. (Keesler Field)	*C*	OX
Binghamton, N. Y. (Tri-City Arpt.)	*C*	TMB
Biorka Island, Alaska	*C*	NQL
Birmingham, Ala. (mun. arpt.)	*C*	BH
Bismarck, N. Dak	*C*	RK
Black Moshannon, Pa	*C*	MJ
Blackstone, Va. (mun. arpt.)	*C*	KT
Blairsville, Pa	*D*	PCE
Blanding, Utah	*D*	PGJ
Blissville, N. B	*CAN*	YS
Block Island, R. I	*D*	HBI
Bloomington, Ill	*D*	PBN
Blue Canyon, Calif	*C*	BC
Blunts Reef Lightship (near Cape Mendocino, Calif.)	*D*	HBF
Blythe, Calif	*C*	YH
Boaz, Ala	*D*	PBE
Boeing Field, Wash. (*See* Seattle.)		
Bogota, Colombia	----	HVW
Bois Blanc Island, Detroit River, Mich	*D*	PJS
Boise, Idaho (Gowan Field)	*C*	BE
Boise, Idaho	*C*	ZBE
Bolling Field, D. C	*W*	WBF
Bonners Ferry, Idaho	*D*	HBO
Borinquen, P. R	*W*	IH
Borinquen, P. R	*D*	HTP
Boston, Mass. (mun. arpt.)	*C*	BW
Boston, Mass	*W*	WBC
Boswell, Pa	*D*	PLR
Botwood, Nfld	*D*	JBO
Boulder City, Nev	*D*	PPA
Bowie, Md	*	FBO
Bowman Field, Ky. (*See* Louisville.)		
Brady, Tex	*D*	HBR
Brainard Airport (*See* Hartford, Conn.)		
Branchville, N. Y		FBV
Bridgeport, Conn	*C*	BP
Brighton, Ohio	*	FBR
Brinkley, Ark	*C*	JW
Bristol, Tenn. (Tri-City Arpt., McKellar Field)	*C*	JB
Broad Pass, Alaska	*D*	HDJ
Broadview, Sask	*CAN*	XB
Brookings, Oreg	*D*	HBK
Brooklyn, N. Y. (Floyd Bennett Arpt.)	*C*	FB
Brooks Field, San Antonio, Tex	*W*	WBR
Brookley Field, Ala. (*See* Mobile.)		
Brookville, Pa	*C*	BR
Brown Deer Commercial Arpt. Wis. (*See* Milwaukee.)		
Brown Field, Va. (*See* Quantico.)		
Brownsville, Tex. (Brownsville Pan-American Arpt.)	*C*	JI
Brownwood, Tex. (Camp Bowie)	*W*	WBN
Brunswick, Ga. (Malcolm B. McKinnon Arpt.)	*C*	TBS

Station	Identification	
Buckstown, Pa	*C*	BQ
Buenaventura, Colombia		HVX
Buffalo, N. Y. (mun. arpt.)	*C*	BJ
Buffalo, Wyo	*D*	PBZ
Buffalo Gap, S. Dak	*D*	PBG
Buffalo Springs, Catalina Is., Calif	*D*	HBX
Buffalo Valley, Nev	*C*	BV
Bull Harbor, Vancouver Is	*D*	LBH
Burbank, Calif. (Lockheed Air Terminal)	*C*	BU
Burgess Field, Uniontown, Pa	*W*	WUX
Burley, Idaho	*C*	BX
Burlington, Iowa (mun. arpt.)	*C*	BN
Burlington, Vt. (mun. arpt.)	*C*	JG
Burlington, Vt. (city off.)	*D*	HBJ
Burns, Oreg	*D*	PBS
Burwell, Nebr	*D*	HBL
Butler, Pa		FBT
Butler, Ga	*C*	TTB
Butte, Mont	*C*	BT
Cabbage Hill, Oreg	*	FCH
Cadillac, Mich	*C*	TCK
Cairo, Ill	*D*	PKI
Calais, Maine	*D*	PCI
Calgary, Alta	*CAN*	YC
Calhan, Colo	*D*	PCH
Cali, Colombia		HVY
California, Iowa	*	FCI
Camaguey, Cuba		HVH
Cambridge, Ohio	*C*	CM
Camocim, Brazil		HTQ
Campeche, Mexico	*D*	HCP
Camp Edwards, Mass	*W*	WCE
Candle, Alaska	*D*	HEX
Candler Field, Ga. (*See* Atlanta.)		
Canton, N. Y	*D*	HCA
Canton, Pa	*D*	PCN
Cantwell, Alaska	*D*	HDZ
Canton Island (PAC)	*C*	OB
Canyon Creek, Alaska	*D*	HDK
Cape Decision, Alaska	*D*	HCD

Station	Identification	
Cape Hatteras, N. C	*N*	NHA
Cape Hinchinbrook, Alaska	*D*	HAQ
Cape Lazo, Vancouver Island	*D*	LCL
Cape Lookout, N. C	*N*	NCL
Cape May, N. J	*N*	OM
Cape Mendicino, Calif. (*See* Blunts Reef Lightship.)		
Cape Race, Nfld	*D*	JCR
Cape Sarichef, Alaska	*D*	PCK
Cape Spencer, Alaska	*D*	HAF
Cape St. Elias, Alaska	*D*	HEA
Capital City Arpt., Mich. (*See* Lansing.)		
Caribou, Maine (mun. arpt.)	*C*	IB
Caripeto, Venezuela		HZG
Carlin, Nev	*	FCN
Carlisle, Pa	*	FCL
Carlsbad, N. Mex	*D*	PCD
Carmen, Mexico		HZL
Carmi, B. C	*CAN*	XO
Carrizozo, N. Mex	*D*	HCZ
Cartagena, Colombia		HVZ
Cartago, Colombia		HTB
Cartwright, Lab	*D*	JCA
Casper, Wyo. (Wardwell Field)	*C*	CW
Cassoday, Kans	*C*	CY
Catalina Island, Calif. (*See* Avalon and Buffalo Springs.)		
Cayenne, F. Guiana		HVU
Cedar Grove, Ind	*	FCG
Central, Alaska	*D*	HJA
Central City, Ill		FCC
Centerville, Ind. (Richmond Arpt.)	*A*	TRM
Chadron, Nebr	*C*	THC
Chafurro, Colombia		HTD
Chandler Field, Calif. (*See* Fresno.)		
Chanute, Kans. (mun. arpt.)	*C*	CZ
Chanute Field, Rantoul, Ill	*W*	NU
Chanute Field, Rantoul, Ill	*WO*	XNU

Station		Identification
Charleston, S. C. (mun. arpt.)	C	CS
Charleston, S. C. (Navy Yard)	N	NCH
Charleston, W. Va. (Wertz Field)	C	KN
Charlevoix, Mich	D	PCX
Charlotte, N. C. (Douglas Mun. Arpt.)	C	CF
Charlotte, N. C	C	ZCF
Charlottetown, P. E. I	CAN	YG
Charles City, Iowa	A	TEY
Chatham, N. B	D	JCH
Chattanooga, Tenn. (Lovell Field)	C	CB
Cheyboygan, Mich	A	TEW
Chehalis, Wash	D	PCB
Cherry Fork, Ohio	C	TUW
Chesterfield, N. W. T	D	KCS
Chetumal, Mexico	D	HCM
Cheyenne, Wyo. (mun. arpt.)	C	CX
Chicago, Ill. (mun. arpt.)	C	CG
Chicago, Ill	ATC	CCG
Chicago, Ill. (Army Reserve Base)	W	WCG
Chicken, Alaska	D	HEN
Chihuahua, Mexico	D	PUU
Chipley, Fla	D	PCF
Chitina, Alaska	D	HGC
Churchill, Man	D	KCH
Cienfuegos, Cuba		HVP
Cincinnati, Ohio	ATC	CCC
Cincinnati, Ohio, (Lunken Field)	C	CC
Circle, Alaska	D	HAO
Circle Hot Springs, Alaska	D	HFH
Clarendon, Tex	C	CP
Clarke City, Que	D	JCC
Clarksburg, W. Va	D	PDQ
Classon Point, N. Y		FCS
Clayton, N. Mex	D	PCL
Cleveland, Ohio (mun. arpt.)	C	CV
Cleveland, Ohio	ATC	CCV
Clifton, Tex		FCF
Clinton, Mo	D	HCN
Coal Creek, Alaska	D	HFC
Coal Harbour, B. C	D	LCH
Coalinga, Calif	D	PCO
Coalville, Utah	A	TCL
Coalville, Utah	*	FCA
Coatzacolcos, Mex	D	HCJ
Cochise, Ariz	C	CJ
Coco Solo, C. Z	D	HCS
Cody, Wyo	D	HCO
Coeur d'Alene, Idaho (Weeks Field)	C	KO
Coffeyville, Kans. (mun. arpt.)	C	TKV
Cokato, Minn	D	HCX
Cold Bay (King Cove) Alaska	C	DI
Coldwater, Ohio	D	HCT
Coldwater, Mich	C	TVW
Coldwater, Miss	*	FCR
Colebrook, B. C	D	HCK
Colorado Springs, Colo	D	PRW
Columbia, Mo. (mun. arpt.)	C	CA
Columbia, S. C. (mun. arpt.)	C	CI
Columbiaville, N. Y	C	UQ
Columbus, Miss	W	NN
Columbus, N. Mex	C	KS
Columbus, Ohio (Port Columbus Arpt.)	C	CO
Columbus, Tex	D	PCS
Colville, Wash	D	HCL
College Park, Md		FCP
Concord, N. H. (mun. arpt.)	C	CN
Concordia, Kans	A	TKK
Coney Island, N. Y		FLI
Connellsville, Pa	W	VO
Copper Center, Alaska	D	HEO
Coppermine, N. W. T	D	LCO
Cordova, Alaska	C	KA
Corfu, N. Y		FCX
Corinth, Miss	D	PXR
Coro, Venezuela		HVV
Corpus Christi, Tex. (Cliff Maus Field)	C	CR
Corpus Christi, Tex	N	NCR
Council, Alaska	D	HED
Cove Valley, Pa	C	RF
Cowley, Alta	CAN	YM

Station		Identification
Cozumel, Yucatan	*D*	PCZ
Craig, Alaska	*D*	HAE
Craig, Colo	*D*	HCQ
Cram Field, Iowa. (*See* Davenport.)		
Cranbrook, B. C	*CAN*	XC
Crawford, Nebr	*D*	PCW
Crescent Valley, B. C	*CAN*	QS
Crestview, Fla	*C*	HW
Crewe, Va	*D*	PCV
Cristobal, C. Z		HVZ
Crooked Creek, Pa		FCK
Crooked Creek, Alaska	*D*	HAZ
Cross City, Fla	*C*	FC
Crystal City, Mo		FCY
Crown Point, N. Mex	*D*	PCP
Crown Point, Oreg	*A*	TKP
Cuba, Tenn	*	FCU
Cucuta, Colombia		HTC
Culiacan, Mex	*D*	PQL
Curry, Alaska	*D*	HEC
Curtis Milwaukee mun. arpt., Wis. (*See* Milwaukee.)		
Curtiss - Steinberg Airport, E. St. Louis, Ill	*A*	TES
Curwensville, Pa	*C*	TGN
Custer, Mont	*C*	CU
Cut Bank, Mont	*D*	TVV
Dacano, Colo	*	FDC
Daggett, Calif	*C*	DG
Dahlgren, Va	*N*	NDA
Dallas, Tex. (Love Field)	*C*	DL
Dale Mabry Field, Fla. (*See* Tallahassee.)		
Danforth, Maine	*D*	PDF
Dansville, N. Y. (mun. arpt.)	*C*	TRI
Dartmouth, N. S	*CAN*	XF
Davenport, Iowa	*D*	PDX
David, Panama		HZE
Dawson, Minn	*D*	HDW
Dawson, Yukon	*D*	LDA
Daytona Beach, Fla. (mun. arpt.)	*C*	DB
Dayton, Ohio (mun. arpt.)	*C*	DY
Dead Tree Point, Queen Charlotte Is	*D*	LDT

Station		Identification
Dearborn, Mich. (Ford Arpt.)		FRL
Dease Lake, B. C	*CAN*	QD
Deering, Alaska	*D*	HAD
Delano, Calif		FDO
Delaware Breakwater, Del	*D*	PLW
Delta, Utah	*C*	VZ
Del Monte, Calif	*D*	PWS
Del Rio, Tex	*D*	PDR
Denver, Colo. (Walter Higgley Arpt.)		FDV
Denver, Colo. (mun. arpt.)	*C*	DV
Des Moines, Iowa (mun. arpt.)	*C*	DM
Des Moines, N. Mex	*D*	PDM
De Soto, Kans	*	FDS
Detour, Mich	*D*	PJA
Detroit, Mich. (mun. arpt.)	*A*	TDO
Detroit, Mich. (Wayne County Arpt.)	*C*	DT
Detroit, Mich	*ATC*	CDT
Detroit, Mich	*C*	ZDT
Detroit River Lighthouse, Detroit, Mich	*D*	PJX
Devils Lake, N. Dak	*D*	PDV
Dickinson, N. Dak	*C*	DC
Dillingham, Alaska	*D*	HDD
Dillon, Mont	*C*	DE
Dodge City, Kans	*A*	TDD
Dolbeau, Que	*D*	KDO
Donner Summit, Calif	*C*	DS
Dothan, Ala. (mun. arpt.)	*C*	NI
Doucet, Que	*D*	KDU
Douglas, Ariz. (mun. arpt.)	*C*	TDU
Douglas, Wyo	*C*	DQ
Douglas Airport, N. C. (*See* Charlotte.)		
Dover, Del		FDD
Downey, Calif. (Vultee Arpt.)		FDA
Drummond, Mont	*C*	DR
Dubois, Idaho	*C*	DZ
Dubuque, Iowa	*A*	TDF
Duluth, Minn. (Williamson Johnson Arpt.)	*C*	DH

Station	Identification	
Duncan Field, San Antonio, Tex	W	WDF
Dungeness, Wash	*	FDW
Dunkirk, N. Y	C	DK
Du Page, Ill		FDP
Du Pont Airport, Wil,-mington, Del		DP
Duran, N. Mex	D	PDN
Durango, Colo	D	PDG
Durham, N. H	D	HDM
Dutch Harbor, Alaska	C	SY
Eagle, Alaska	D	PEG
Eagle Harbor, Mich	D	PJB
Earlton Junction, Ont	CAN	XR
East Dayton, Ohio (Commercial Airport). (*See* Vandalia.)		
East Liverpool, Ohio	A	TEZ
East Pembroke, N. Y	*	FEP
East St. Louis, Ill	D	TES
East Waterford, Pa	D	PBK
Easton, Wash	C	TP
Eastport, Maine	D	PEA
Edgewood Arsenal, Md	W	WEG
Ediz Hook, Wash. (Port Angeles)	G	GEH
Edmonton, Alta	CAN	XD
Effingham, Ill	C	EF
Egbert, Wyo	*	FEG
Ela, N. C	D	PEL
Eldorado, Ark	D	PEO
Eldred Rock, Alaska	D	HEL
Elizabeth City, N. C	D	PEM
Elk City, Okla	D	PEY
Elkins, W. Va. (mun. arpt.)	C	EK
Elko, Nev. (mun. arpt.)	C	EL
Ellensburg, Wash	C	EB
Ellington Field, Houston, Tex	W	IV
Ellis, Kans	D	HES
Elmira, N. Y	C	EA
El Morro, N. Mex	C	EM
El Paso, Tex. (mun. arpt.)	C	EO
Ely, Nev	D	PEV
Elyria, Ohio		FEY
Engle, N. Mex	C	EX
Enid, Okla	W	ET
Enterprise, Utah	C	NP
Ephrata, Wash	C	EP
Erie, Pa. (Port Erie Arpt.)	C	ER
Escanaba, Mich	A	TEC
Estero, Calif	D	PES
Estevan, B. C	D	LES
Etter, Minn	*	FET
Eugene, Oreg	C	EU
Eureka, Calif	D	PEU
Evansville, Ind. (mun. arpt.)	C	EV
Everett, Wash. (Paine Field)	C	MI
Everett, Wash	C	ZMI
Evergreen, Ala	C	TEN
Excelsior Springs, Mo	*	FES
Fairbanks, Alaska (Fairbanks Arpt.)	C	FX
Fairbanks, Alaska (W. B. Office)	D	HFX
Fairbanks, Alaska (Ladd Field)	W	WFX
Fairfax Field, Kansas City, Kans	W	WRD
Fairview, Alta	D	LFA
Fairview, Tenn	*	FFW
Falmouth, Mass. (Camp Edwards)	W	WCE
Fame Point, Que	D	JFA
Fargo, N. Dak. (Hector Field)	C	FO
Farralon Island, Calif. (*See* S. E. Farralon Island.)		
Farwell, Alaska	C	LU
Father Point, Que		JFP
Felts Field, Wash. (*See* Seattle.)		
Findlay, Ohio	C	TJF
Fisherville, Tenn	*	FFV
Five Finger Light, Alaska	D	HFF
Flagstaff, Ariz	D	PFF
Flat, Alaska	D	HFL
Flat Top, W. Va	D	PFL
Flint, Mich. (Bishop Arpt.)	D	TFN

Station	Identification	
Florence, S. C. (mun. arpt.)	*C*	FL
Floyd Bennett Arpt. (*See* Brooklyn, N. Y.)		
Floyd Bennett Field, N. Y.	*C*	ZFB
Fly Field, Ariz. (*See* Yuma.)		
Fogo, Nfld	*D*	JFG
Fond du Lac, Wis	*A*	FU
Fontana, Calif	*	FFN
Fontana, Calif	*D*	PFN
Forked River, N. J		FFR
Forney, Tex	*	FFT
Fortaleza, Brazil		HTR
Fort Benning, Ga. (Lawson Field)	*WO*	XVL
Fort Benning, Ga. (Lawson Field)	*W*	VL
Fort Bliss, El Paso, Tex	*W*	WBL
Fort Bragg, Fayetteville, N. C	*WO*	XOP
Fort Bragg, Calif	*D*	PFB
Fort Bridger, Wyo	*C*	HM
Fort Brown, Brownsville, Tex	*S*	SBR
Fort Clark, Eagle Pass, Tex	*S*	SCL
Fort Collins, Colo	*D*	PFC
Fort Crockett, Galveston, Tex	*W*	WFC
Fort Custer, Battle Creek, Mich	*W*	WJC
Fort Davis, Panama	*W*	FA
Fort Dix, N. J	*W*	WFD
Fort Graham, B. C	*CAN*	YQ
Fort Gratiot, Mich	*D*	PJD
Fort Jackson, S. C	*W*	WCI
Fort Jones, Calif	*C*	FJ
Fort Knox, Ky. (Godman Field)	*W*	WKX
Fort Leavenworth, Kans. (Sherman Field)	*W*	LW
Fort Lewis, Tacoma, Wash	*W*	WFL
Fort McClellan, Anniston, Ala	*W*	WRF
Fort McIntosh, near Corpus Christi, Tex	*S*	SMC
Fort McPherson, Atlanta, Ga	*W*	WFM
Fort Monmouth, Trenton, N. J	*W*	WMM
Fort Myers, Fla. (Lee County Arpt.)	*A*	FM
Fort Nelson, B. C	*CAN*	YE
Fort Norman, N. W. T	*D*	LNO
Fort Oglethorpe, Chattanooga, Tenn	*W*	WFO
Fort Pembina Airport. (*See* Pembina, N. Dak.)		
Fort Plain, N. Y	*C*	TFP
Fort Riley, Kans. (Marshall Field)	*W*	FY
Fort Ringgold, Rio Grande, Tex	*S*	SRG
Fort St. John, B. C	*CAN*	XJ
Fort Sam Houston, San Antonio, Tex	*W*	WSH
Fort Sill, Okla. (Post Field)	*W*	FI
Fort Simpson, N. W. T	*D*	LSI
Fort Smith, Ark	*A*	THS
Fort Wayne, Ind. (Baer Field)	*W*	WFW
Fort Wayne, Ind. (mun. arpt.)	*C*	FW
Fort Wayne, Ind	*C*	ZFW
Fort Worth, Tex	*ATC*	CFV
Fort Worth, Tex. (Meacham Field)	*C*	FV
Fort Wright, Fishers Island, Long Island, N. Y	*W*	WFI
Fort Yukon, Alaska	*D*	PWI
Frances Lake, B. C	*D*	LFL
Frankfort, Mich	*D*	PFK
Frederick, Md	*C*	TFD
Fredericton, N. B	*D*	JFR
Fresno, Calif. (mun. arpt.)	*C*	FT
Fresno, Calif	*C*	ZFT
French Frigate Shoals (PAC)	*C*	AM
Frostburg, Md	*D*	PFR
Frontenac, Minn	*C*	FE
Front Royal, Va	*C*	FZ
Gage, Okla	*C*	VM
Gainesville, Tex	*C*	GE

Station		Identification
Galveston, Tex. (mun. arpt.)	*C*	GS
Gamble, Alaska	*D*	HAG
Garden City, Kans. (mun. arpt.)	*C*	GK
Gardner, Kans	*D*	PNR
Garrison, N. Dak	*D*	PGA
Gassaway, W. Va	*D*	PZW
Genesee, Wis	*	FGA
Geneseo Field, Kans	*D*	PGF
Georgetown, B. Guiana		HVO
Geraldine, Mont	*D*	PGD
Gerona, Cuba	*D*	PGE
Gilroy, Calif		FGL
Gladwin, Mich	*C*	TGU
Glasgow, Mont	*D*	PGL
Glencoe, Ont	*CAN*	QI
Glendale, Calif	*D*	TGX
Glens Falls, N. Y. (mun. arpt.)	*C*	TGQ
Glendive, Mont	*D*	PGN
Glenview, Ill. (Curtis-Reynolds)	*N*	NCG
Gods Lake, Man	*D*	KGL
Golden Gate Bridge, Calif.		FGG
Goleta, Calif. (*See* Santa Barbara.)		
Golovin, Alaska	*D*	HGL
Golva, N. Dak	*C*	GA
Gooding, Idaho	*C*	GG
Goodland, Kans	*D*	PGK
Good Paster, Alaska	*D*	HGP
Gordonsville, Va	*C*	GJ
Goshen, Ind	*C*	GO
Grand Bank, Nfld	*D*	JGB
Grand Canyon, Ariz	*D*	PGC
Grand Coulee, Wash	*D*	PGZ
Grand Forks, N. Dak. (mun. arpt.)	*C*	GF
Grand Island, Nebr. (mun. arpt.)	*C*	GI
Grand Junction, Colo	*A*	TEG
Grand Marias, Minn	*D*	PJC
Grand Prairie, Alta	*CAN*	QU
Grand Rapids. Mich. (Kent Co. Arpt.)	*C*	GR
Grangeville, Idaho	*D*	HGV
Great Falls, Mont	*C*	GT
Greeley, Colo	*D*	PGY

Station		Identification
Green Bay, Wis	*A*	TGB
Greencastle, Ind	*	FGS
Greenfield, Ind	*	FGF
Green River, Utah	*D*	PGR
Greensboro, N. C. (Greensboro-Highpoint Arpt.)	*C*	GW
Greensboro-Highpoint Arpt. (*See* Greensboro.)		
Greenville, Ill		FGV
Greenville, N. C	*D*	PGV
Greenville, Me	*D*	PGI
Greenville, S. C. (mun. arpt.)	*A*	GC
Greenwood, Miss	*C*	GD
Grindstone Is., Que	*D*	JGR
Grosse Isle, Mich	*N*	NGI
Grove City, Pa		FGC
Guadalajara, Mex	*D*	HGJ
Guadalupe Pass, Tex	*	FGP
Guadalupe Pass, Tex	*D*	TGP
Guam Island (PAC)	*C*	GP
Guana Juato, Mex	*D*	PGH
Guane, Cuba	*D*	PGU
Guantánamo, Cuba	*D*	PGM
Guard Island, Alaska	*D*	HGI
Guatemala, Guatemala		HZK
Guaymas, Mexico	*D*	PGX
Gulkana, Alaska	*C*	XV
Gunter Field, Montgomery, Ala	*WO*	XUG
Gustavus, Alaska	*C*	NE
Hadley Field, New Brunswick, N. J	*D*	THE
Haileybury, Ont	*D*	KHY
Haines, Alaska	*C*	VN
Haleakala, Hawaii	*D*	HLK
Hale Field, Mont. (*See* Missoula.)		
Hamel, Minn	*	FHL
Hamilton, Bermuda		JBM
Hamilton Field (Near San Rafael, Calif.)	*W*	HO
Hancock, Iowa	*	FHI
Hancock, Nebr	*	FUH
Harbor Beach, Mich	*D*	HRB
Harlingen, Tex	*W*	WHT
Harrington, Que		JHR
Harrington, Wash	*D*	PHT

Station	Identification	
Harrington Ranch, Tex	*	FHR
Harrisburg, Pa. (State arpt.)	C	HX
Hartford, Conn. (Brainard Arpt.)	C	HT
Harvey, Ill	C	GH
Hatbox Field (Muskogee, Okla.)	W	HF
Hatteras, N. C	D	PHA
Havana, Cuba	D	PHV
Havre, Mont	A	THV
Hawkins, Tex		FHW
Hawthorne, Nev	D	HAW
Haycock, Alaska	D	HOL
Hayes Center, Nebr	C	KB
Hayesville, Ohio	C	HA
Healy, Alaska	D	HHY
Hearst Ranch, Calif. (*See* San Simeon.)		
Hector Field, N. Dak. (*See* Fargo.)		
Helena, Mont	C	HL
Hensley Field, Ft. Worth, Tex	W	HY
Herbert Smart Field, Ga. (*See* Macon.)		
Hermosillo, Mex	D	HHS
Herndon, Va	*	FHN
Hershey, Nebr		FUA
Hickam Field, Oahu, T. H	D	HMO
Hickory, N. C	D	PIA
Hickory, Pa	*	FHY
Hicksville, Ohio		FHC
Highland, Ill		FHA
Highland Park, Ill		FHP
Hill Field, Ogden, Utah	W	WOG
Hilo, Hawaii	C	UF
Hinckley, Minn	D	PHK
Hinckley, Ill		FUB
Hobart, Wash	*	FHT
Hobbs, N. Mex	D	PHB
Hog River, Alaska	D	HJB
Hollister, Calif	D	PHO
Holman Municipal Arpt., Minn. (*See* St. Paul.)		
Holy Cross, Alaska	D	HDH
Homer, Alaska	C	VQ
Homerville, Ohio	*	FHO

Station	Identification	
Homestead, Molokai	D	HOM
Honolulu, Oahu, T. H	C	HZ
Hood River, Oreg	D	HHR
Hookstown, Pa	*	FHK
Hoonah, Alaska	D	HEH
Hooper Bay, Alaska	D	HDB
Hope, B. C	D	LHO
Hopes Advance, Que	D	JHA
Hot Springs, Alaska	D	HAI
Hot Springs, N. C	D	PHG
Houlton, Me. (mun. arpt.)	C	HJ
Houlton, Me	C	ZHJ
Houghton, Mich	D	HHN
Houghton Lake, Mich	D	HHO
Houston, Tex. (Howard Hughes Arpt.)	C	HU
Howard Field, C. Z	W	OE
Howland Island (PAC)	C	UD
Hubbard Field, Nev. (*See* Reno.)		
Hudson Hope, B. C	D	LHH
Hueco Mt., Tex	*	FHM
Hughes, Ark	*	FHG
Hughes, Alaska	D	HHU
Humboldt, Nev	C	HD
Humeston, Iowa		FHS
Hunter Field, Ga. (*See* Savannah.)		
Huntington, W. Va. (Mayes Field, Chesapeake, Ohio)	C	HI
Huntington, Vt	*	FHU
Huntsville, Ala	D	PHL
Huron, S. Dak. (W. W. Howes Arpt.)	C	HR
Hutchinson, Kans. (mun. arpt.)	C	HN
Huntsville, Ohio	D	PHD
Hyannis, Mass	D	PHY
Hybla Valley, Va		FHV
Hydaburg, Alaska	D	HAY
Idaho Falls, Idaho	C	IF
Ilio, T. H	C	IY
Iliamna, Alaska	C	JP
Imperial Beach, Calif	*	FIJ
Independence, Calif	D	HIN
Indianapolis, Ind. (mun. arpt.)	C	ID

Station		Identification
Indianapolis, Ind. (Hoosier Arpt.)		FID
Indio, Calif	*C*	IN
Inyokern, Calif	*D*	PIK
Iowa City, Iowa (mun. arpt.)	*A*	IX
Iowa Falls, Iowa	*D*	PIF
Iprates, Colombia		HTE
Island of Lanai (HWI)	*D*	HLI
Isle Royal, Mich	*D*	PJE
Ithaca, N. Y	*D*	PIT
Jacks Creek, Tenn	*C*	JK
Jackson, Mich. (Reynolds Field)	*C*	TJN
Jackson, Miss. (Hawkins Field)	*C*	JA
Jackson, Miss	*C*	ZJA
Jacksonville, Fla. (mun. arpt.)	*C*	JX
Jacksonville, Fla. (Naval Air Base)	*N*	NJX
Jacksonville, Fla	*C*	ZJX
Jackwade, Alaska	*D*	HEJ
Jamestown, N. Dak	*C*	JM
Japonski Island, Sitka, Alaska	*N*	NSJ
Jarvis, Ont	*CAN*	QZ
Jarvis Island (PAC)	*C*	JV
Jasper, Alta	*D*	LJA
Jerseyville, Ill		FJV
Johnston Island (PAC)	*C*	AU
Johnston's Ranch, Tex	*S*	SJR
Joliet, Ill. (mun. arpt.)	*C*	JO
Jordan, Minn	*	FJO
Joshua, Tex	*	FJT
Judiths Gap, Mont	*D*	PJG
Juneau, Alaska (Juneau Arpt.)	*C*	JE
Juneau, Alaska (W. B. office)	*D*	HJE
Justin, Tex		FJS
Kain's Island, B. C	*D*	LKQ
Kalamazoo, Mich	*D*	PHU
Kalispell, Mont	*D*	PKA
Kalskag, Alaska	*D*	PKK
Kaltag, Alaska	*D*	HGK
Kamloops, B. C	*D*	LKA
Kanaga, Alaska	*D*	PKG
Kanatak, Alaska	*D*	HAK
Kane, Pa	*D*	PKP
Kansas City, Mo. (mun. arpt.)	*C*	KC
Kapuskasing, Ont	*CAN*	YU
Kasilof, Alaska	*D*	HGF
Keddie Field, Nev. (*See* Elko).		
Kedgewick, N. B	*D*	JKD
Keg River, Alta	*D*	LKR
Kelso, Wash	*C*	HP
Kellogg, Idaho	*D*	PKD
Kelly Field, San Antonio, Tex	*W*	KF
Kenai, Alaska	*C*	JS
Kenora, Ont	*CAN*	QK
Kenosha, Wis	*	FKW
Kenton, Ohio		FKT
Kent County Arpt., Mich. (*See* Grand Rapids.)		
Keokuk, Iowa	*D*	PKE
Kern County Arpt., Calif. (*See* Bakersfield.)		
Kernville, Calif	*D*	PKL
Keesler Field, Miss. (*See* Biloxi.)		
Ketchikan, Alaska	*C*	KG
Ketchikan, Alaska (W. B. office)	*D*	HKG
Key Field, Miss. (*See* Meridian, Miss.)		
Keyser Ridge, Md	*D*	PKR
Key West, Fla. (Meacham Arpt.)	*C*	KW
Killaloe, Ont	*CAN*	XI
Kimberly, B. C	*CAN*	QE
Kimshan Cove, Alaska	*D*	HKC
King City, Calif. (Palo Alto Arpt.)	*A*	TT
King County Arpt. (*See* Seattle.)		
King Hill, Idaho	*C*	KH
King Island, Alaska	*D*	HEI
Kingman, Ariz. (Port Kingman)	*C*	KI
Kingston, Ont	*D*	KKI
Kingsville, Tex		FKE
Kirksville, Mo	*C*	KR

Station	Identification	
Klukwan, Alaska	D	HFK
Knapp Creek, N. Y	D	PKN
Knolls, Utah	D	PKO
Knoxville, Mo	C	KL
Knoxville, Tenn. (mun. arpt.)	C	KX
Kodiak, Alaska	C	OF
Kitzbue, Alaska	D	HEZ
Koyuk, Alaska	D	HYO
Kukuihaele, Hawaii	D	HNK
Kylertown, Pa	A	TKY
Lac Dore (Chibougamau), Que	D	KCB
La Crosse, Wis. (La Crosse Co. Arpt.)	C	LE
La Crosse Co. Arpt., Wis. (*See* La Crosse.)		
Lafayette, Ind. (Purdue University Arpt.)	C	LF
Lafayette, La., (mun. arpt.)	C	TZL
La Grange, Oreg	C	IU
La Grange, Ga	D	HGN
La Guaira, Venezuela		HZA
La Guardia Field, N. Y	C	LG
La Habra, Calif	*	FLH
La Junta, Colo. (mun. arpt.)	C	LH
Lake Charles, La. (mun. arpt.)	C	LC
Lake Charles, La	W	GZ
Lake Charles, La	C	ZLC
Lake Minchumina, Alaska	C	IQ
Lakehurst, N. J	N	LP
Lakeland, Fla	A	TLL
Lake Carey, Pa		FCB
Lake Placid, N. Y	D	PLK
Lakeview, Oreg	D	PVW
Lamar, Colo	D	PLA
Lambert Field Mun. Arpt., Mo. (*See* St. Louis.)		
Lamoni, Iowa	C	TFR
Lander, Wyo	D	PLD
Lane, S. C	C	TLX
Langara, B. C	D	LLA
Langley Field, Hampton, Va	W	LY
Langley Field, Hampton, Va	WO	XLY
Lansing, Mich. (Capitol City Arpt.)	C	LJ
Lansing, Ill		FLS
Lansing Shoals, Mich	D	PJF
La Paz, Mexico	D	HLP
Laquey, Mo		FLQ
Laramie, Wyo. (mun. arpt.)	C	LR
Laredo, Tex	D	PLO
Larkspur, Colo	D	PLS
Lasoya, Tex	*	FLT
Las Cruces, N. Mex	D	PZS
Las Vegas, Nev. (McCarran Field)	C	LQ
Las Vegas, Nev	C	ZLQ
Las Vegas, N. Mex. (mun. arpt.)	C	VH
Latrobe, Pa		FLB
Laupahoehoe, Hawaii	D	HLH
Lavina, Mont	D	PLQ
Lawton, Okla. (*See* Fort Sill.)		
Lawson Field, Fort Benning, Ga	WO	XVL
Lawson Field, Fort Benning, Ga	W	VL
Layton, Utah	*	FLN
Leadville, Colo	D	PLC
Lebanon, N. J	*	FLE
Lebanon, N. H	D	HLN
Lebec, Calif	*	FLC
Lebo, Kans	C	LN
Lemmon, S. Dak	D	PLM
Le Pas, Man	D	LPS
Lerdo, Mexico	D	PLY
Lethbridge, Alta	CAN	QL
Lewiston, Me	D	PAS
Lewistown, Mont	C	IT
Lexington, Ky	D	PLE
Lihue, Kauai	D	HOZ
Lincoln, Maine	D	PLI
Lincoln, Nebr. (Lindbergh Field)	A	HK
Linda Vista, Calif	D	PLV
Lindbergh Field, Calif. (*See* San Diego.)		

Station		Identification
Lindley Field N. C. (*See* Greensboro.)		
Little Port Walter, Alaska	*D*	HDF
Little Rock, Ark. (Adams Field)	*C*	LI
Little Rock, Ark	*C*	ZLI
Lively, Va	*C*	VE
Livengood, Alaska	*D*	HEE
Live Oak, Fla	*C*	TOI
Livermore, Calif.	*C*	LM
Livingston, Mont. (Zollman Field)	*C*	LT
Locomotive Springs, Utah	*C*	LO
Locust Grove, Ga	*	FLV
Logan, W. Va	*D*	PLN
Logan Field, Md. (*See* Baltimore.)		
London, Ont	*CAN*	XU
Lone Rock, Wis	*C*	LK
Long Beach, Calif. (mun. arpt.)	*C*	HB
Long Beach, Calif	*C*	ZHB
Long Grove, Ill		FLD
Los Angeles, Calif. (Nat. Guard, Griffith Park)	*W*	WLA
Los Angeles, Calif. (mun. arpt.)	*C*	LA
Los Angeles, Calif. (city office, W. B.)	*D*	PLX
Los Angeles, Calif	*ATC*	CBU
Los Angeles, Calif	*C*	ZLA
Lordsburg, N. Mex	*W*	WLO
Losey Field, P. R	*W*	DJ
Louisville, Ky. (Bowman Field)	*C*	LV
Louisville, Ky	*C*	ZLV
Lovell Field, Tenn. (*See* Chattanooga.)		
Lowell, Ind	*	FLO
Lowry Field, Denver Colo	*W*	JT
Lubbock, Tex	*W*	HH
Lufkin, Tex	*D*	PLB
Lunken Field, Ohio. (*See* Cincinnati.)		
Luray, Mo		FLR
Luxora, Ark		FLX
Lynchburg, Va. (Preston Glenn Arpt.)	*C*	LB

Station		Identification
MacDill Field (Tampa, Fla.)	*W*	VT
McChesney Arpt., Ill. (*See* Rockford.)		
Mackinaw City, Mich	*D*	PJH
Macon, Ga. (Herbert Smart Field)	*C*	UN
Madison, Ind. (Jefferson Proving Grounds)	*W*	WMI
Madison, Wis. (mun. arpt.)	*C*	MA
Madras, Ga	*	FMG
Maine, Ariz	*C*	MW
Makena, Is. of Maui (PAC)	*C*	GM
Malcolm B. McKinnon Field. (*See* Brunswick, Ga.)		
Malden, Mo	*C*	TNB
Maljamar, N. Mex	*D*	PMJ
Malton, Ont	*CAN*	YZ
Managua, Nicaragua	*D*	HMN
Manchester, N. H. (mun. arpt.)	*W*	UR
Manchester, N. H	*W*	ZUR
Manitou Isle, Mich	*D*	PJI
Mankato, Minn	*D*	PMO
Manuas, Brazil		HTS
Manzanillo, Mexico	*D*	PWO
Maracaibo, Venezuela		HZB
March Field, Riverside, Calif	*W*	WMZ
Marfa, Tex	*W*	WMA
Marias, Mexico	*D*	HAR
Marietta, Okla	*	FMF
Marquette, Mich	*C*	TTE
Marshall, Mo	*A*	TMH
Marshall, Alaska	*D*	HEM
Martinsburg, W. Va. (Shepherd Field)	*C*	MR
Mary Island, Alaska	*D*	HFM
Marysville, Mich		PJU
Mason City, Iowa (mun. arpt.)	*C*	TNM
Mason Springs, Md	*	FMS
Matamoros, Mexico	*D*	PXS
Matanuska, Alaska	*D*	HDT
Mather Field, Sacramento, Calif	*W*	IM

Station	Identification	
Maxwell Field, Montgomery, Ala	*W*	XW
Maxwell Field, Montgomery, Ala	*WO*	XXW
Mayo, Yukon	*CAN*	LMA
Mazatlan, Mexico	*D*	PXN
McAlester, Okla	*D*	PML
McChord Field, Tacoma, Wash	*W*	TA
McClellan Field. (*See* Sacramento Air Depot.)		
McCool, Ind	*C*	ML
McDonald, Mont	*	FMD
McDougall Field, Idaho. (*See* Pocatello.)		
McGrath, Alaska	*C*	WH
McKellar Field, Va. (*See* Bristol.)		
McKinley Park, Alaska	*D*	HEY
McMurray, Alta.	*CAN*	XZ
Meacham, Oreg	*D*	PAM
Medellin, Colo		HTG
Medford, Oreg	*C*	MF
Media, Pa		FMA
Medicine Hat, Alta	*CAN*	XH
Megantic, P. Q	*CAN*	XG
Melbourne, Fla. (Melbourne-Eau Gallie Arpt.)	*C*	OU
Memorial Airport, S. C. (*See* Spartanburg.)		
Memphis Tenn., (mun. arpt.)	*C*	PS
Mercer, Pa	*C*	MC
Merida, Mexico	*D*	PXM
Meridian, Miss. (Key Field)	*C*	UM
Meridian, Miss	*C*	ZUM
Merrill Field. (*See* Anchorage, Alaska.)		
Mesa, Ariz	*	FMB
Metuchen, N. J		FMN
Mexicali, Mexico		HZO
Mexico City, Mexico	*D*	PXX
Miami, Fla. (Chapman Field)	*W*	WCH
Miami, Fla. (mun. arpt.)	*C*	MM
Miami, Fla. (Naval Reserve Air Base)	*N*	NOL

Station	Identification	
Michigan City, Ind		FMC
Middletown, Pa. (Olmstead Field)	*W*	WMT
Middletown, Pa. (Olmstead Field)	*WO*	XMT
Midland, Tex	*C*	ZON
Midway Island (PAC)	*C*	KM
Midwest, Wyo	*D*	PID
Miles City, Mont	*C*	MY
Milesville, S. Dak	*D*	PME
Milford, Utah	*C*	MD
Millertown, Nfld	*D*	JMI
Millinocket, Maine (mun. arpt.)	*C*	MT
Miller, S. Dak	*D*	PMS
Millis, Mass	*	FMM
Milroy, Ind	*C*	MV
Milwaukee, Wis. (General Mitchell Field)	*C*	MK
Milwaukee Air Terminal, Wis	*D*	PMT
Milwaukee County Mun. Arpt., Wis. (*See* Milwaukee.)		
Minchumina, Alaska	*D*	HMC
Mineola, Mo		FNP
Mines Field, Calif. (*See* Los Angeles.)		
Minititlan, Mexico		HZM
Minneapolis, Minn. (Wold-Chamberlain Arpt.)	*C*	MP
Minnedosa, Man	*D*	LMI
Minot, N. Dak	*C*	UI
Mission, Tex	*W*	DX
Missoula, Mont. (Hale Field)	*C*	MX
Mitchel Field, Long Island, N. Y	*W*	WM
Mitchel Field, Long Island, N. Y	*WO*	XWM
Mobile, Ala. (Bates Field)	*C*	MS
Mobridge, S. Dak	*D*	PMP
Moclips, Wash	*D*	HMP
Modena, Utah	*D*	PMA
Modesto, Calif. (mun. arpt.)	*C*	OD
Moffett Field (near Mountain View, Sunnyvale, Calif.)	*W*	SW

Station		Identification
Mogollon, N. Mex	D	HMQ
Moline, Ill. (mun. arpt.)	C	MO
Moncton, N. B	CAN	QM
Monee, Ill		FMI
Monroe, La. (Selman Field)	C	UO
Monroeville, Ala	D	HMV
Montague, Calif. (mun. arpt.)	A	TMU
Monte Vista, Colo	D	PMV
Monteagle, Tenn	C	ME
Monterey, Calif	D	PUY
Monterey, Mexico	D	PXY
Montezuma, Iowa	C	MZ
Montgomery, Ala. (Gunter Field)	A	TUG
Monticello, Ark	D	HMZ
Montpelier, Ohio		FMQ
Montreal, P. Q	CAN	UL
Monument, Colo	D	HMU
Moose Creek, Alaska	C	PM
Moose Jaw, Sask		LMJ
Moosonee, Ont	D	KMO
Morelia, Mexico	D	HMR
Morgantown, W. Va	D	PMB
Mormon Mesa, Nev	C	NZ
Morris Plains, N. J		FMJ
Morrison Field, Fla. (*See* West Palm Beach.)		
Morrisville, Pa	*	FMV
Morse, Ill	C	MQ
Morse Field, Hawaii	D	HMF
Moscow, Mich		FMW
Moses Point, Alaska	C	HG
Mottville, Mich		FMT
Moultrie, Ga	W	IC
Mt. Ayr, Iowa	D	HMY
Mt. Eden, Calif		FME
Mt. Hamilton, Calif	D	PMH
Mt. Laguna, Calif	D	PMD
Mt. Leonard, Mo	*	FLF
Mt. Liberty, Ohio	*	FML
Mt. Mitchell, N. C	D	HMM
Mt. Orab, Ohio	*	FMO
Mt. Pocono, Pa	C	TKU
Mt. Prospect, Ill	*	FMP
Mt. Shasta, Calif	C	SC
Mt. Tamalpais, Calif	D	PTS
Mt. Tamalpais, Calif		FTS
Mt. Union, Pa		FMU
Mt. Vernon, Wash	D	PVO
Mt. Washington, N. H	D	HMW
Mt. Wilson, Calif	D	PMW
Mountainair, N. Mex	D	PMR
Mullan Pass, Mont	C	MN
Murfreesboro, Tenn	*	FMR
Muroc, Calif	W	UC
Muscle Shoals, Ala. (TVA Arpt.)	C	ED
Muskegon, Mich. (county arpt.)	C	UK
Muskogee, Okla. (*See* Hatbox Field.)		
Muskoka, Ont	CAN	QA
Nakina, Ont	CAN	QN
Naknek, Alaska	C	KD
Nantucket, Mass	D	PEH
Napaimute, Alaska	D	HDN
Nashville, Tenn. (Berry Field)	C	NA
Nashville, Tenn	C	ZNA
Nassau, B. W. I	D	PNU
Navasota, Tex	C	NT
Neah Bay (Cape Flattery) Wash	C	KQ
Needles, Calif	C	NJ
Nelson, B. C	CAN	XQ
Nenana, Alaska	D	HFN
Neosho, Mo	C	NS
New Alexandria, Pa	*	FNA
New Bedford, Mass	D	PNB
New Brunswick, N. J	*	FNB
New Carlisle, Ind		FNC
New Florence, Mo	C	ST
New Hackensack, N. Y	C	NX
New Haven, Conn. (mun. arpt.)	A	TNV
New Orleans, La. (mun. arpt.)	C	NO
New Orleans, La	C	ZNO
New York City, La Guardia Field	C	LG
New York, N. Y. (city office W. B.)	D	HNY
New York, N. Y. (Coast Guard Comm. Center)	G	GNY

Station		Identification
New York, N. Y. (mun. arpt.)	ATC	CNY
New York, N. Y. (Pan American Oper. Office, La Guardia Arpt.)		PNY
New York University, Bronx, N. Y., N. Y	D	PYO
Newalla, Okla		FND
Newark, N. J. (mun. arpt.)	C	NK
Newark, N. J. (National Guard)	W	WNK
Newark, Ohio	*	FNO
Newark, Ill	*	FNK
Newcastle, Wyo	D	HNC
Newfoundland Arpt., Nfld		JNP
Newhall, Calif	C	NH
Newhall Pass, Calif	*	FNH
Newport, Oreg	D	PNP
Newport, Vt	D	HNV
Niagara Falls, N. Y. (mun. arpt.)	A	NF
Nichols Field, P. I	W	OQ
No Grub, Alaska	D	HEB
Nome, Alaska (mun. arpt.)	C	YO
Norfolk, Va. (mun. arpt.)	C	NW
Norfolk, Va. (Chambers Field)	N	NR
Norman, Okla		FNG
Normandy, Ill		FUD
Norris Arm, Nfld	D	PNS
Norristown, Pa		FUJ
North Bay, Ont	CAN	YB
North Bend, Oreg	D	PNW
North Bend, Wash	D	PZB
North Beverly, Mass	*	FNM
North Island, Calif. (San Diego Naval Air Sta.)	N	NNI
North Liberty, Ind		FNL
North Platte, Nebr. (mun. arpt.)	C	NQ
North Springfield, Pa	*	FGD
North West River, Lab	D	JNW
Northbrook, Ill. (Sky Harbor Arpt.)	D	IR
Northdalles, Wash	C	ND
Northfield, Vt	D	PNF
Northhead, Wash	D	PNH

Station		Identification
Norway House, Man	D	LNH
Nottingham Island, N. W. T	D	KNO
Nulato, Alaska	D	HNU
Nunivak, Alaska	D	HDX
Oakland, Calif. (mun. arpt.)	C	OA
Oakland, Calif	ATC	COA
Oaxaca, Mexico	D	HOX
Obregon, Mexico	D	HOB
Ocala, Fla	D	POC
Ocean City, Md		FON
Oceanside, Calif	C	OC
Offutt Field, Ft. Cook, Omaha, Nebr	W	WOF
Ogden, Utah (mun. arpt.)	C	OG
Ogden, Utah (Hill Field)	W	ZE
Oil City, Pa		FOL
Oklahoma City Okla. (Will Rogers Field)	C	OL
Oklahoma City, Okla	C	ZOL
Olathe, Kans		FOE
Oliver, B. C	D	LOL
Olmstead Field, Pa. (*See* Middletown.)		
Olympia, Wash. (mun. arpt.)	A	TOY
Omaha, Nebr. (mun. arpt.)	C	OH
Ontario, Oreg	C	OO
Opa Locka Naval Reserve Base, Fla	N	NOL
Ophir, Alaska	D	HDI
Orlando, Fla.	C	OR
Orlando, Fla	C	ZOR
Orlando, Fla	W	WOR
Oroville, Wash	D	HOR
Oswego, N. Y	D	POW
Ottawa, Ontario	CAN	OW
Otto, N. Mex	C	OT
Ottumwa, Iowa	C	GV
Otu, Colombia		TH
Overton, Nebr	C	OV
Oxford, Kans	*	FOF
Pachena, Vancouver Is., B. C	D	LPC

Station		Identification
Page Field, Beaufort, S. C. (*See* Parris Island.)		
Pagwa, Ont	*CAN*	XK
Palacios, Tex	*C*	UX
Palanquero, Colombia		HTI
Palestine, Tex	*A*	TPZ
Palm Springs, Calif	*A*	TUP
Palm Beach County Arpt., Fla. (*See* W. Palm Beach.)		
Palma, N. Mex		FPM
Palmdale, Calif	*C*	PA
Palmyra Island (PAC)	*C*	JY
Pampa, Tex. (mun. arpt.)	*A*	TJZ
Panama City, Fla	*W*	KE
Paramaribo, Dutch Guiana		HVT
Parco, Wyo	*C*	XP
Paris, Tenn	*D*	HPS
Parkersburg, W. Va	*A*	TVG
Park Falls, Wis	*D*	HPF
Parkland, Wash	*	FPD
Parkman, Ohio		FPN
Park Place, Pa	*C*	TPL
Parks Airport, East St. Louis, Ill	*D*	PAK
Parris Island, S. C. (Page Field)	*N*	NPI
Parry Sound, Ont	*D*	KPS
Pasadena, Calif	*D*	PPJ
Pasco, Wash	*D*	PPZ
Paso Robles, Calif. (Paso Robles Field)	*C*	TPV
Pato, Colombia		HTJ
Patterson, La	*D*	PLF
Patterson Field, Dayton, Ohio	*W*	PK
Paul Cox Airport, Ind. (*See* Terre Haute.)		
Paxson, Alaska	*D*	HAX
Paxton Springs, N. Mex	*D*	PPO
Peace River, Alta	*CAN*	YR
Pearson Field, Wash. (Vancouver)	*W*	WPF
Pearl Harbor, T. H. (Naval Air Station)	*N*	NHU
Pellston, Mich. (mun. arpt.)	*C*	TPJ
Pembina, N. Dak. (Fort Pembina Arpt.)	*C*	PB
Pendleton, Oreg	*C*	PO
Pendleton, Oreg	*C*	ZPO
Penhold, Alta	*CAN*	QF
Pensacola, Fla	*A*	TYP
Pensacola, Fla. (U. S. Naval Air Station)	*N*	NC
Penticton, B. C	*CAN*	YF
Peoga, Ind	*	FPE
Peoria, Ill. (mun. arpt.)	*C*	PI
Peoria Mun. Arpt., Ill. (*See* Peoria.)		
Perry, Ohio	*C*	PE
Perryville, Ariz	*	FPV
Petersburg, Alaska	*C*	UJ
Petersburg, W. Va	*D*	HPG
Philadelphia, Pa	*N*	NPN
Philadelphia, Pa. (mun. arpt.)	*C*	PG
Philadelphia, Pa. (Nat. Guard)	*W*	WNG
Philip, S. Dak	*C*	IL
Phillips Field, Md. (*See* Aberdeen.)		
Phillipsburg, Kans	*D*	PPH
Phoenix, Ariz. (Sky Harbor Arpt.)	*C*	PH
Pickle Lake, Ont	*D*	KPL
Pierce County Arpt., Wash. (*See* Tacoma.)		
Pierces Ferry, Ariz	*D*	PVF
Pierre, S. Dak. (mun. arpt.)	*C*	PX
Pikeville, Ky	*D*	HPI
Pilot Point, Alaska	*D*	HEP
Pine Camp, N. Y. (Wheeler-Sack Field)	*W*	WPC
Pine Bluff, Ark	*D*	PBF
Pine Bluffs, Wyo	*D*	PPB
Pittsburg, Ill		FPT
Pittsburgh, Pa	*W*	WPI
Pittsburgh, Pa. (Allegheny County Arpt.)	*C*	PT
Pittsburgh, Pa	*ATC*	CPT
Pittsburgh, Pa. (Bettis Field)		FBD
Pittsfield, Mass	*C*	TFG
Platinum, Alaska	*D*	PPM
Plattsburg, Mo		FPB
Platte City, Mo	*	FPL

Station		Identification
Plymouth, Utah	*C*	UH
Pocatello, Idaho (McDougall Field)	*C*	PQ
Poes Reef (Cheboygan), Mich	*D*	PJJ
Point Arena, Calif	*D*	HPO
Point Arguello, Calif	*D*	HPA
Point Fermin, Calif	*D*	PPF
Point Hope, Alaska	*D*	HDQ
Point Hueneme, Calif	*D*	PPF
Point Montara, Calif	*D*	HPM
Point No Point, Wash	*D*	PPN
Point Piedras Blancas, Calif	*D*	HPB
Point Reyes, Calif	*D*	HPY
Point Lay, Alaska	*D*	HDS
Ponca City, Okla. (mun. arpt.)	*C*	TPC
Pontiac, Mich	*D*	PGG
Pope Field, Ft. Bragg, Fayetteville, N. C	*W*	OP
Porquis Jct., Ont	*CAN*	QJ
Port Allen, Kauai, T. H	*C*	OZ
Port Angeles, Wash. (*See* Ediz Hook.)		
Port Arthur (Ft. Williams), Ont	*CAN*	QT
Port Arthur, Tex	*A*	EE
Port au Prince, Haiti		HVR
Port Chester, N. Y	*	FPC
Port de France, Martinique		HVL
Port Harrison, Que	*D*	KPH
Port Heiden, Alaska	*C*	ZG
Port Huron, Mich	*D*	PJT
Port Limon, Costa Rica		HVE
Port Royal, Va		FPR
Port of Spain, Trinidad		HVM
Port Townsend, Wash	*A*	TFQ
Port Washington, L. I., N. Y		PF
Port Washington, L. I., N. Y. (PAA)		PPW
Portage, Alaska	*D*	HAP
Portage, Mich	*D*	PJK
Portage, Pa		FPG
Portland, Oreg. (Portland-Columbia Arpt.)	*C*	PD
Portland, Oreg. (Swan Island Arpt.)	*D*	PPS
Portland-Columbia Arpt., Oreg. (*See* Portland.)		
Portland, Oreg	*C*	ZPD
Portland, Maine (mun. arpt.)	*C*	PW
Portland, Maine (city office)	*D*	HPD
Porto Velho, Brazil		HTT
Potrero Hill, Calif	*C*	PY
Prairie Du Rocher, Ill	*D*	PRU
Pratt, Kans	*D*	PPT
Prescott, Ariz	*D*	TUE
Presque Isle, Maine	*W*	ZQ
Presque Isle, Maine	*C*	ZZQ
Preston Glenn Arpt., Va. (*See* Lynchburg.)		
Prince Albert, Sask	*D*	LPA
Prince George, B. C	*D*	LPG
Prince George, B. C	*CAN*	XS
Prince Rupert, B. C	*D*	LPR
Princeton, B. C	*CAN*	QP
Progreso, Mex	*D*	PXO
Providence, R. I. (R. I. State Arpt.)	*A*	PR
Provincetown, Mass	*D*	PNC
Pueblo, Colo. (mun. arpt.)	*C*	PU
Pulaski, Va	*C*	US
Puntilla, Alaska	*D*	HDY
Purdue University Arpt., Ind. (*See* Lafayette.)		
Putnam, Conn	*C*	PN
Pylgrim, Alaska	*D*	HFY
Quanah, Tex	*D*	PQH
Quantico, Va. (Brown Field)	*N*	NQN
Qu'Appelle, Sask	*D*	LQA
Quebec, P. Q	*CAN*	QB
Quincy, Ill	*D*	PQY
Quonset Point, R. I. (Naval Air Station)	*N*	NQP
Radioville, Alaska	*D*	HFR
Rainbow, Alaska	*D*	HJC
Raleigh, N. C. (mun. arpt.)	*C*	RA

Station	Identification	
Randolph Field, San Antonio, Tex	*W*	RQ
Rapid City, S. Dak. (mun. arpt.)	*C*	RZ
Rapids, Alaska	*D*	PRS
Raton, N. Mex. (mun. arpt.)	*C*	TMG
Ravenswood, W. Va		FRV
Rawlins, Wyo	*D*	PRL
Raymondville, Tex	*D*	PRV
Reading, Pa	*D*	PRN
R. E. Byrd Airport, Va. (*See* Richmond.)		
Recife, Brazil		HVA
Red Bluff, Calif. (Bidwell Arpt.)	*C*	FH
Redding, Calif. (Benton Field)	*A*	TRG
Red Lake, Ont		KRL
Red Rock, Ariz	*	FRR
Reeves Field, San Pedro, Calif	*N*	RU
Regina, Sask	*CAN*	QR
Reno, Nev. (United Arpt.)	*C*	RP
Rensselaer, Ind		FRN
Resolution, N. W. T	*D*	JRE
Reynolds Mun. Arpt., Mich. (*See* Jackson.)		
Richardson, Alaska	*D*	HFU
Richlands, Va	*D*	PRM
Richmond, Va. (R. E. Byrd Arpt.)	*C*	RW
Ridgecrest, N. C	*D*	PRC
Rio Hata, Panama	*W*	RE
Rivers, Man	*CAN*	YI
Riverside, Calif	*C*	RV
Riverside, Calif. (*See* March Field.)		
Riverton, Utah	*	FRU
Roanoke, Va. (mun. arpt.)	*C*	RO
Robertson Field Mun. Arpt., Mo. (*See* St. Louis.)		
Rochester, Minn	*C*	RR
Rochester, N. Y. (mun. arpt.)	*C*	RC
Rockaway Beach, N. Y		FRB
Rockford, Ill. (McChesney Arpt.)	*C*	RD
Rockport, Mass	*D*	PRK
Rock Springs, Wyo. (mun. arpt.)	*C*	RT
Rocky Mount, N. C	*D*	PUT
Rodeo, N. Mex	*C*	RH
Rolla, Mo	*C*	TRJ
Roseburg, Oreg	*A*	TRB
Rosecrans Field, Mo. (*See* St. Joseph.)		
Roswell, N. Mex	*A*	EH
Ross, N. W. T	*D*	LRO
Rowe, N. Mex	*D*	PRX
Roosevelt Field, L. I., N. Y	*D*	PEX
Ruby, Alaska	*C*	RX
Rumford, Maine	*D*	HRU
Sable Island, N. S	*D*	JSA
Sacramento, Calif. (mun. arpt.)	*C*	XZ
Sacramento Air Depot, (McClellan Field, Sacramento, Calif.)	*W*	WSZ
Safety, Alaska	*D*	HFS
Saginaw, Mich. (mun. arpt.)	*A*	SI
Salem, Oreg	*A*	TSX
Salina Cruz, Mex	*D*	PZZ
Salinas, Calif. (mun. arpt.)	*C*	ZS
Salinas, Calif	*C*	ZZS
Saline, Mich	*	FSA
Salisbury, Md	*D*	HSA
Salmon, Idaho	*D*	HSM
Salt Flat, Tex	*C*	DN
Salt Lake City, Utah (mun. arpt.)	*C*	SL
Salt Lake City, Utah	*ATC*	CSL
Salt Lake City, Utah	*C*	ZSL
San Angelo, Tex. (Goodfellow Field)	*W*	IP
San Antonio, Tex. (Stinson Field)	*C*	ZN
San Antonio, Tex. (Portable)	*C*	SG
San Clemente Is., Calif	*N*	NSC
San Diego, Calif. (Lindbergh Field)	*C*	SQ
San Francisco, Calif. (city office)	*D*	HSF

Station		Identification
San Francisco, Calif. (mun. arpt.)	A	SF
San Francisco Bay Airdrome, Calif. (See Alameda)		
San Jose, Calif		FZE
San Jose, Costa Rica		HZI
San Juan, P. R	D	HSJ
San Julian, Cuba		HVG
San Marco, Colombia		HTK
San Miguel Is., Calif	D	PSL
San Nicolas Island (Coast of Calif.)	D	HSN
San Pedro de Macoris, Dom. Republic		HVS
San Pedro, Calif. (See Reeves Field)		
San Rafael, Calif. (See Hamilton Field)		
San Salvador, Salvador		HZJ
San Simeon, Calif		FSS
Sand Island, Honolulu, T. H	W	VP
Sand Point, Seattle, Wash.	N	NSP
Sand Point, Alaska	D	HDA
Sandberg, Calif	A	TZB
Sanderson, Tex	D	PST
Sandgirt Lake, Lab	D	JSL
Sandia Mt., N. Mex	*	FSM
Sandy Hook, N. J	D	PSH
Sanmaur, Que	D	KSM
Santa Ana, Calif	D	PHS
Santa Barbara, Calif. (mun. arpt.)	C	TZR
Santa Fe, N. Mex. (mun. arpt.)	C	TZK
Santa Maria, Calif	D	TZM
Santarem, Brazil	D	HTV
Santiago, Cuba	D	HVK
Santo, Tex	C	ZA
Sao Luiz, Brazil		HTW
Sarasota, Fla	D	PEB
Saskatoon, Sask	CAN	XE
Sault Ste. Marie, Mich. (mun. arpt.)	C	VC
Sault Ste. Marie, Ont	CAN	YY
Savannah, Ga. (Hunter Field)	C	SH
Savannah, Ga	C	ZSH

Station		Identification
Savoonga, Alaska	D	HAV
Schenectady, N. Y	D	PCR
Schoen Field, Ft. Benj. Harrison, Indianapolis, Ind	W	WCN
Scottdale, Pa	*	FSC
Scott Field, Belleville, Ill	W	CD
Scotch Cap, Alaska	D	HFD
Scottsbluff, Nebr. (mun. arpt.)	C	TF
Scranton, Pa	D	PED
Scranton, Pa. (downtown W. B.)	D	PSN
Seattle, Wash. (Boeing Field)	C	SA
Seattle, Wash	ATC	CSA
Secret Peak, Nev	*	FSP
Selawick, Alaska	D	HDO
Selfridge Field, Mt. Clements, Mich	W	LD
Seligman, Ariz		FSL
Selkirk, Yukon	CAN	QQ
Selma, Ala	W	PP
Sentinel Is., Alaska	D	HFI
Seward, Alaska	D	HFE
Sexton Summit, Oreg	C	ZX
Seymour, Ind	D	PSR
Sheridan, Ill		FSH
Sheridan, Wyo. (mun. arpt.)	C	ZY
Sherman-Denison, Tex	W	WSD
Sherman Field, Fort Leavenworth, Kans	W	LW
Shishmaref, Alaska	D	HFV
Sholtz Field, Fla. (See Daytona Beach.)		
Shreveport, La. (mun. arpt.)	C	ZH
Shungnak, Alaska	D	HFJ
Sidney, Nebr	C	SD
Sidney Is., B. C	CAN	YJ
Sikeston, Mo		FSO
Silver Crown, Wyo	*	FSV
Silver Lake, Calif	C	RL
Simpson, D. M., N. W. T	D	PZN
Sioux City, Iowa (mun. arpt.)	C	YX
Sioux Falls, S. Dak. (mun. arpt.)	C	YL

Station		Identification
Sioux Lookout, Ont	CAN	XL
Siskiyou Summit, Oreg	A	TSK
Sitka, Alaska (W. B. city office)	D	SJ
Sitka, Alaska (Japonski Island)	N	NSJ
Skagway, Alaska	D	HGS
Skiatook, Okla		FSK
Skwentna, Alaska	D	PSK
Sky Harbor Airport, Ill. (*See* Chicago.)		
Slatington, Pa	*	FSN
Slave Lake, Alta	CAN	QV
Sleitmute, Alaska	D	HFQ
Sloan Field, Midland, Tex	W	ON
Smiths Grove, Ky	C	SO
Smithers, B. C	CAN	YD
Smithville, Tenn	C	XM
Smyrna, Ga	*	FSR
Snoqualamie Pass, Wash	D	PQM
Snow Hill, Md	D	PSD
Socorro, N. Mex	C	TOS
Soloman, Alaska	D	HEF
Sorel, P. Q	CAN	YT
South Bend, Ind. (Bendix-St. Joseph County Arpt.)	C	SN
South Boston, Va	C	SB
South Manitou Is., Mich	D	PJM
Southampton, Ont	D	KSO
S. E. Farallon Island, Calif	D	PFI
Spangle, Wash	*	FSE
Spartanburg, S. C. (Memorial Arpt.)	C	SU
Spearfish, S. Dak. (Black Hills Arpt.)	C	TSE
Spencer, Iowa	D	HSP
Spokane, Wash. (Geiger Field)		FGW
Spokane, Wash. (Felts Field)	C	SM
Spring Bluff, Mo	C	FF
Springer, N. Mex	D	PSP
Springfield, Ill. (mun. arpt.)	C	ZF
Springfield, Mass	D	ZV
Springfield, Mass	D	PWJ
Springfield, Minn	D	PSM
Springfield, Mo	C	ZF
Squantum, Mass. (Naval Reserve Aviation Base)	N	NBW
Squaw Harbor, Alaska	C	CE
Stamford, Conn		FST
Stampede, Alaska	D	HFA
Stampede Pass, Wash	D	PSW
Stanford, Mont	D	PSF
Stearns, Ky	D	HST
Stephentown, N. Y	*	FPH
Stevens, Alaska	D	HDG
Stevens Field, Wyo. (*See* Rock Springs.)		
Stevenson, Wash	C	LZ
Steward Field (West Point, N. Y)	W	WWP
Stirling, Ont	CAN	QC
St. Clair Flats, Mich	D	PJV
St. Cloud, Minn	A	TZC
St. George, Ill		FSI
St. Georges, Nfld	D	JSG
St. Hubert, P. Q	D	VXS
St. Ignace, Mich. (Mackinac Co. Arpt.)	C	TZI
St. Johns, Antigua		HVN
St. John, N. B	D	JSJ
St. John's, Nfld	D	JJN
St. Joseph, Mo. (Rosecrans Field)	C	ZJ
St. Louis, Mo	ATC	CLS
St. Louis, Mo. (mun. arpt.)	C	LS
St. Louis, Mo. (Lambert Field, mun. arpt.)	W	WLS
St. Louis, mun. arpt., Mo. (*See* St. Louis.)		
St. Michael, Alaska	D	HDC
St. Paul, Alaska	D	PPP
St. Paul, Minn. (mun. arpt.)	A	TZP
St. Paul Is., N. S	D	JSP
St. Peters, Mo		FPS
St. Petersburg, Fla	D	PCC
St. Simons Is., Ga. (*See* Brunswick, Ga.)		
St. Thomas, Virgin Islands	D	PSV
St. Xavier, Mont	D	PSX
Stockton, Calif	W	JH

Station	*Identification*	
Stockton, Utah	*D*	PKX
Stone Mt., Ga	*	FSG
Stonyriver, Alaska	*D*	HDE
Story City, Iowa	*C*	TSS
Stout Field, Indianapolis, Ind	*W*	WST
Strevell, Idaho	*D*	ZT
Sturgeon Bay, Wis	*D*	PJL
Sulphur Springs, Tex	*C*	TZO
Summit, Alaska	*C*	JD
Summerhill, Pa	*	FSU
Sumter, S. C. (Shaw Field)	*W*	WSF
Sunbury, Pa	*A*	SV
Sunnyvale, Calif. (*See* Moffett Field)		
Superior, Mont	*C*	SP
Susanville, Calif	*D*	HSU
Swan Island, Oreg. (*See* Portland.)		
Swan Island, Caribbean	*C*	IK
Swift Current, Sask	*CAN*	YN
Sydney, N. S	*D*	JSY
Syracuse, N. Y. (mun. arpt.)	*C*	SR
Tacubaya, Mex	*D*	PTB
Taft, Calif	*D*	HTF
Taku Lodge, Alaska	*D*	HEU
Talkeetna, Alaska	*C*	AO
Tallahassee, Fla. (Dale Mabry Field)	*C*	TJ
Tallahassee, Fla	*C*	ZTJ
Tame, Colombia		HTL
Tampa, Fla. (MacDill Field)	*W*	WT
Tampa, Fla. (Peter O. Knight Arpt.)	*C*	TM
Tampico, Mexico	*D*	PTK
Tanalian Point, Alaska	*D*	HGT
Tanana Crossing, Alaska	*C*	TW
Tanana, Alaska	*C*	KZ
Tapachula, Mexico	*D*	PTL
Tarkio, Mo	*C*	TTK
Tatoosh, Wash	*D*	PTA
Tawas Point, Mich	*D*	PJO
Taylor, Alaska	*D*	HDP
Tegucigalpa, Honduras		HVF
Tejeria, Mexico		HZF

Station	*Identification*	
Tejon, Calif		FTJ
Teller, Alaska	*D*	HAT
Tenakee, Alaska	*D*	HET
Terminal Is., San Pedro, Calif. (*See* Reeves Field.)		
Terre Haute, Ind. (Paul Cox Arpt.)	*C*	TH
Tetlin, Alaska	*D*	HGZ
Tewksbury, Mass	*	FTW
Texarkana, Ark. (mun. arpt.)	*C*	TR
Ticonderoga, N. Y	*C*	TTQ
Timpie, Utah	*	FTM
Tintic, Utah	*C*	TX
Thomasville, Ga	*D*	PTH
Thornton, Ill		FTH
Thunder Bay Is., Mich	*D*	PJN
Toledo, Ohio (mun. arpt.)	*C*	TL
Toledo, Wash	*C*	GL
Tombstone, Ariz	*D*	PTF
Tongue Point, Oreg	*N*	NTP
Tonopah, Nev	*D*	PTU
Topeka, Kans	*A*	TTO
Topeka, Ind		FTP
Toronto, Ont	*CAN*	YZO
Townsend, Mont	*D*	HTO
Tracy, Calif		FTC
Trail, Oreg	*	FTL
Transatlantic Operating Rooming (WSY/LG). (*See* LG.)		
Transatlantic Receiving Station (Barnegat, N. J.)	*C*	TBR
Transatlantic Transmitter Station (Sayville, N. Y.)	*C*	TSA
Transcontinental Mun. Arpt., Ohio. (*See* Toledo.)		
Traverse City, Mich	*C*	TG
Tree Point, Alaska	*D*	HFT
Trenton, N. J	*A*	TTN
Trenton, Ont	*D*	KTR
Tri-City Airport. (*See* Bristol, Tenn.)		
Trinidad, Colo. (mun. arpt.)	*C*	TD
Triple Island, B. C		LTI

Station	Identification	
Troutdale, Oreg	*D*	PTJ
Troy, Ohio		FTY
Tucson, Ariz. (mun. arpt.)	*C*	TZ
Tucumcari, N. Mex	*C*	TC
Tulancimgo, Mex		HTX
Tulsa, Okla. (mun. arpt.)	*C*	TS
Tulsa, Okla	*C*	ZTS
Tupelo, Miss	*D*	HTU
Turbo, Colombia		HZD
Turks Island, W. I	*D*	PTW
Turner Field, Ga. (*See* Albany.)		
Tuscaloosa, Ala. (Hargrove Van de Graaf Field)	*C*	TTU
Tuskegee, Ala	*W*	NL
Tuxpem, Mexico		HZN
Two Rivers, Wyo		FTR
Tyler, Tex. (mun. arpt.)	*C*	TV
Tylertown, Miss	*C*	TY
Tyonek, Alaska	*D*	HGY
Ucluelet, B. C	*D*	LUT
Umnak Island, Alaska	*C*	RS
Unalakleet, Alaska	*D*	HAU
Unalaska, Alaska	*C*	VJ
Underwood, N. Dak	*C*	TUZ
Union, Ky	*	FUO
Union, Mich		FMH
Union Air Term., Calif. (*See* Burbank.)		
Upolu Point, T. H	*C*	AD
Urbanna, Va	*D*	PUR
Utica, N. Y. (mun. arpt.)	*C*	UA
Vail, Ariz	*	FVL
Valdez, Alaska	*C*	KJ
Valdosta, Ga	*W*	UU
Valentine, Nebr	*A*	TVA
Valpariso, Fla. (Eglin Field)	*W*	WEF
Vancouver, B. C	*CAN*	VR
Vancouver, Wash. (*See* Pearson Field.)		
Van Nuys, Calif. (metropolitan arpt.)		FVY
Ventosa, Nev	*C*	VX
Vera Cruz, Mex	*D*	PVZ
Vermillion, Ohio	*	FVM
Vero Beach, Fla. (mun. arpt.)	*C*	TVB
Vickery, Ohio	*C*	VK
Vicksburg, Miss. (mun. arpt.)	*C*	TVS
Victoria, B. C	*CAN*	VI
Victoria, Tex	*W*	VF
Victorville, Calif	*W*	EQ
Villavicencio, Colombia		HTM
Villahermosa, Guatemala	*D*	PVG
Vincennes, Ind		FVN
Visalia, Calif		FVC
Waco, Tex. (Rich Field)	*C*	WC
Wadsworth, Nev	*	FWN
Wake Island (PAC)	*C*	DW
Wales, Alaska	*D*	HEW
Walla Walla, Wash	*C*	WL
Walsenburg, Colo	*D*	HWA
Wamsutter, Wyo	*C*	WQ
Warm Springs, Mont	*D*	HWS
Warren, Ohio	*C*	WE
Warrenton, N. C	*C*	TWN
Warsaw, Ky	*C*	WR
Washburn, Tex		FWC
Washington, D. C. (National Arpt.)	*C*	WA
Washington, D. C	*ATC*	CWA
Washington, Ind	*D*	PWA
Washougal, Wash	*	FWA
Watson Lake, B. C	*CAN*	QH
Waterman, Ill	*A*	TWT
Watertown, S. Dak. (mun. arpt.)	*C*	WU
Waterville, Maine	*D*	PNA
Watsonville, Calif		FWY
Watkins, Colo	*	FUF
Wausau, Wis	*D*	HWU
Waxahachie, Tex	*	FWX
Wayne County Arpt., Mich. (*See* Detroit.)		
Waynoka, Okla	*A*	TWY
Weatherford, Tex	*	FWE
Weeks Field, Idaho. (*See* Coeur d'Alene.)		
Wenatchee, Wash	*D*	PWB
Wendover, Utah	*C*	WV
Westfield, Mass. (Barnes Arpt.)	*C*	WJ

Station		Identification
Westover Field, Springfield, Mass	W	OJ
Westview, Ohio		FWV
West Palm Beach, Fla. (Morrison Field)	C	TWZ
West Palm Beach, Fla	C	ZWZ
West Plaines, Mo	D	HWP
West Point (Stewart Field), N. Y	W	WWP
Wetmore, Tex	*	FWT
Wheatland, Wyo	D	PHJ
Wheeling, W. Va	D	PWE
Wheeler Field, Oahu, T. H	D	HNW
Whiteface Mountain, N. Y	D	PWF
Whitefish Point, Mich	D	PJP
Whitehall, Mont	C	WW
Whitetail, Mont	*	FWS
Whitehorse, Yukon	CAN	XY
White Mountain, Alaska	D	HFW
White River, Ont	D	KWR
White Rock, Colo	D	PWR
White River Jct., Vt. (Twin State Arpt.)	C	TZW
Wichita, Kans. (mun. arpt.)	C	WD
Wichita Falls, Tex. (Kell Field)	C	WF
Wichita Falls, Tex	C	ZWF
Wilkes-Barre, Pa. (mun. arpt.)	C	WI
Wilmington, Calif	D	PWM
Wilmington, Del. (DuPont Arpt.)	A	DP
Wilmington, N. C	A	TWC
Wilmington, Ohio	*	FWO
Willamette, Oreg	*	FWD
Williamsburg, Ky	D	PWG
Williams, Calif	C	WS
Williams Lake B. C		LWL
Williamsport, Pa	C	IA
Williston, N. Dak	A	TTI
Willmar, Minn	C	1W
Wills Point, Tex		FWP
Willoughby, Ohio		FWB
Wilson, Ill		FWQ
Winchester, Ky	D	HWI
Winder, Ga	C	IG
Windsor, Ont	CAN	QG
Windsor Locks, Conn	W	VU
Wingfoot Lake, Ohio		FWL
Wink, Tex	C	WP
Winnemucca, Nev	A	TEJ
Winnipeg, Man	CAN	WG
Winslow, Ariz. (TWA Arpt.)	C	WO
Winston-Salem, N. C	D	PSU
Winston, Mont	*	FWM
Winston, N. C	D	PWT
Wixom, Mich	*	FWI
Wiseman, Alaska	D	HFZ
Wold-Chamberlain Mun. Arpt., Minn. (See Minneapolis.)		
Wolf Creek, Oreg	D	HWC
Woodland, Wash	*	FWW
Wood River, Ill	*	FWR
Woodward, Pa	C	WK
Woodward Field, Utah. (*See* Salt Lake City.)		
Wrangell, Alaska	D	PWL
Wright Field, Dayton, Ohio	W	WWF
Wytheville, Va	D	PWY
Yakataga, Alaska	C	ZZ
Yakima, Wash	C	YA
Yakutat, Alaska	C	VY
Yakutat, Alaska	W	WVY
Yarmouth, N. S	CAN	JYA
Yellowstone, Wyo	D	PYE
Yoakum, Tex	C	YK
Youngstown, Ohio (mun. arpt.)	C	CT
Yuma, Ariz. (mun. arpt.)	D	PYU
Zacatecas, Mex	D	HZS
Zollman Field, Mont. (*See* Livingston.)		

c. *Radio call letters—alphabetically by call letters.*

Call letters	Station
KCJ	Everett, Wash. (intercontinental).
KCQ	St. Louis, Mo.
KCR	Boise, Ida.

Call letters	Station
KCS	Las Vegas, Nev.
KCT	Los Angeles, Calif.
KCU	Fresno, Calif.
KCV	Oakland, Calif.
KCX	Medford, Oreg.
KCY	Portland, Oreg.
KCZ	Seattle, Wash.
KDA	Chicago, Ill.
KDN	Rock Springs, Wyo.
KGD	Salt Lake City, Utah
KIS	Anchorage, Alsk. (intercontinental).
KJF	Omaha, Neb.
KKJ	Fort Worth, Tex.
KLK	Reno, Nev.
KME	Strevell, Ida.
KOJ	Elko, Nev.
KRC	Kansas City, Mo.
KSF	San Francisco, Calif. (intercontinental).
KSG	Cheyenne, Wyo.
KVM	Honolulu, Oahu, T. H. (intercontinental).
KCAA	Tulsa, Okla.
KCAB	Sidney, Neb.
KCAC	Butte, Mont.
KCAD	Idaho Falls, Ida.
KCAE	Winslow, Ariz.
KCAF	Albuquerque, N. M.
KCAG	Amarillo, Tex.
KCAH	Kingman, Ariz.
KCAI	Tucumcari, N. M.
KCAJ	Little Rock, Ark.
KCAK	Shreveport, La.
KCAL	Willmar, Minn.
KCAM	Tucson, Ariz.
KCAN	Fargo, N. D.
KCAO	El Paso, Tex.
KCAP	Big Spring, Tex.
KCAQ	Minneapolis, Minn.
KCAR	Pueblo, Colo.
KCAS	Spokane, Wash.
KCAT	Milford, Utah
KCAU	Houston, Tex.
KCAV	Springfield, Mo.
KCAW	San Antonio, Tex.
KCAX	Daggett, Calif.
KCAY	Missoula, Mont.
KCAZ	Miles City, Mont.
KCBS	Maine, Ariz.
KCBT	Acomita, N. M.
KCBU	Otto, N. M.
KCBV	Minot, N. D.
KCBW	Cassoday, Kan.
KCBX	Fort Bridger, Wyo.
KCBY	Columbus, N. M.
KCBZ	El Morro, N. M.
KCCA	Oklahoma City, Okla.
KCCB	Phoenix, Ariz.
KCCC	Santo, Tex.
KCCD	Palmdale, Calif.
KCCE	Locomotive Springs, Utah
KCCF	Rodeo, N. M.
KCCG	Canton Island, Pac.
KCCH	Wink, Tex.
KCCI	Clarendon, Tex.
KCCJ	Ashfork, Ariz.
KCCL	Donner Summit, Calif.
KCCM	Midway Island, Pac.
KCCN	Cochise, Ariz.
KCCO	Anton Chico, N. M.
KCCP	Newhall, Calif.
KCCQ	Abilene, Tex.
KCCR	Wichita Falls, Tex.
KCCS	Ardmore, Okla.
KCCT	Potrero Hills, Calif.
KCCU	Moline, Ill.
KCCV	Lebo, Kan.
KCCW	Howland Island, Pac.
KCCX	Coeur d'Alene, Ida.
KCCY	Ellensburg, Wash.
KCCZ	Ephrata, Wash.
KCDA	Douglas, Wyo.
KCDB	Ft. Worth, Tex. (central depot).
KCDC	Neosho, Mo.
KCDD	Grand Forks, N. D.
KCDE	Spring Bluff, Mo.
KCDF	Superior, Mont.
KCDG	Drummond, Mont.
KCDH	Helena, Mont.
KCDI	Belgrade, Mont.
KCDJ	Livingston, Mont.
KCDK	Billings, Mont.
KCDL	Custer, Mont.
KCDM	Stevenson, Wash.
KCDN	Pembina, N. D.
KCDO	Watertown, S. D.

Call letters	Station
KCDP	Navasota, Tex.
KCDQ	Golva, N. D.
KCDR	Dickinson, N. D.
KCDS	Fairbanks, Alsk.
KCDT	Waco, Tex.
KCDU	Pendleton, Oreg.
KCDV	Bismarck, N. D.
KCDW	Anchorage, Alsk. (domestic).
KCDX	Jamestown, N. D.
KCDY	Alexandria, Minn.
KCDZ	Advance, Mo.
KCEA	Buffalo Valley, Nev.
KCEB	Columbia, Mo.
KCEC	Sexton Summit, Oreg.
KCED	Atlantic, Ia.
KCEE	Ventosa, Nev.
KCEF	Beowawe, Nev.
KCEG	Big Springs, Neb.
KCEH	Blue Canyon, Calif.
KCEI	Burley, Idaho
KCEJ	Burlington, Ia.
KCEK	Wamsutter, Wyo.
KCEL	Wichita, Kan.
KCEM	Akron, Colo.
KCEN	Des Moines, Ia.
KCEO	Oceanside, Calif.
KCEP	Gainesville, Tex.
KCEQ	North Platte, Neb.
KCER	Humboldt, Nev.
KCES	La Grande, Oreg.
KCET	Laramie, Wyo.
KCEU	Livermore, Calif.
KCEV	Montezuma, Ia.
KCEW	Mount Shasta, Calif.
KCEX	New Florence, Mo.
KCEY	Northdalles, Wash.
KCEZ	Easton, Wash.
KEAA	Juneau, Alsk.
KEAB	Wendover, Utah
KEAC	Williams, Calif.
KEAD	Wake Island, Pac.
KEAE	Casper, Wyo.
KEAF	Pocatello, Ida.
KEAG	Blythe, Calif.
KEAH	Enterprise, Utah
KEAI	Lewistown, Mont.
KEAJ	Dallas, Tex.
KEAK	Texarkana, Ark.
KEAL	Arlington, Oreg.
KEAM	Mullan Pass, Mont.
KEAN	Grand Island, Neb.
KEAO	San Diego, Calif.
KEAP	Whitehall, Mont.
KEAQ	Austin, Tex.
KEAR	Auburn, Calif.
KEAS	Baker, Oreg.
KEAT	Bakersfield, Calif.
KEAU	Brownsville, Tex.
KEAW	Corpus Christi, Tex.
KEAX	Delta, Utah
KEAY	Denver, Colo.
KEAZ	Dillon, Mont.
KEOA	Dubois, Ida.
KEOB	Eugene, Oreg.
KEOC	Galveston, Tex.
KEOD	Sioux City, Ia.
KEOE	Great Falls, Mont.
KEOF	Indio, Calif.
KEOG	Silver Lake, Calif.
KEOH	Long Beach, Calif.
KEOI	Plymouth, Utah
KEOJ	Chanute, Kan.
KEOK	Mormon Mesa, Nev.
KEOL	Needles, Calif.
KEOM	Parco, Wyo.
KEON	Riverside, Calif.
KEOO	Sheridan, Wyo.
KEOP	Sacramento, Calif.
KEOQ	Rochester, Minn.
KEOR	Palacios, Tex.
KEOS	Tintic, Utah.
KEOT	Tyler, Tex.
KEOU	Cordova, Alsk.
KEOV	Red Bluff, Calif.
KEOW	Overton, Neb.
KEOX	Trinidad, Colo.
KEOY	Lake Charles, La.
KEOZ	Ft. Jones, Calif.
KEQA	Gage, Okla.
KEQB	Las Vegas, N. M.
KEQC	Modesto, Calif.
KEQD	Brinkley, Ark.
KEQE	Beaumont, Tex.
KEQF	Ketchikan, Alsk.
KEQG	Huron, S. D.
KEQH	Bellingham, Wash.
KEQI	Sioux Falls, S. D.

Call letters	Station
KEQJ	Ontario, Oreg.
KEQK	Everett, Wash. (domestic).
KEQL	Toledo, Wash.
KEQM	Hayes Center, Neb.
KEQN	Blanding, Utah
KEQO	Nome, Alsk.
KEQP	Frontenac, Minn.
KEQQ	Ruby, Alsk.
KEQR	Summit, Alsk.
KEQS	Talkeetna, Alsk.
KEQT	Haines, Alsk.
KEQU	Sitka, Alsk.
KEQV	Petersburg, Alsk.
KEQW	Yakutat, Alsk.
KEQX	Aberdeen, S. D.
KEQY	Yoakum, Tex.
KEQZ	Engle, N. M.
KHDA	Aniak, Alsk.
KHDB	Kelso, Wash.
KHDC	Lincoln, Neb.
KHDE	Gooding, Ida.
KHDF	Farewell, Alsk.
KHDG	Big Delta, Alsk.
KHDH	Gulkana, Alsk.
KHDI	Moose Creek, Alsk.
KHDJ	Honolulu, Oahu, T. H. (domestic).
KHDK	Kenai, Alsk.
KHDL	Lake Minchumina, Alsk.
KHDM	Valdez, Alsk.
KHDN	Tanana Crossing, Alsk.
KHDO	Ilio, T. H.
KHDP	Ottumwa, Ia.
KHDQ	Walla Walla, Wash.
KHDR	Madison, Wis.
KHDS	Seward, Alsk.
KHDT	Tanana, Alsk.
KHDU	Upolu Point, T. H.
KHDV	St. Joseph, Mo.
KHDW	San Francisco, Calif. (domestic).
KHDY	Iowa City, Ia.
KMZA	Hilo, Hawaii, T. H.
KMZB	Port Allen, Kauai, T. H.
KMZC	Johnston Island, Pac.
KMZD	Palmyra Island, Pac.
KMZE	Jarvis Island, Pac.
KMZF	French Frigate Shoals, Pac.
KMZG	Kodiak, Alsk.
KMZH	McGrath, Alsk.
KMZI	Bethel, Alsk.
KMZJ	La Junta, Colo.
KMZK	Hutchinson, Kan.
KMZL	Yakima, Wash.
KMZN	Duluth, Minn.
KMZP	Monroe, La.
KMZR	Makena, Maui, T. H.
KMZS	Alliance, Neb.
KMZT	Garden City, Kan.
KMZU	Ogden, Utah.
KMZV	Salt Flat, Tex.
KMZY	Naknek, Alsk.
KMZZ	Moses Point, Alsk.
WBP	Key West, Fla.
WEK	New Orleans, La. (intercontinental).
WFT	Guantánamo, Cuba.
WNR	Richmond, Va.
WRW	San Juan, P. R.
WSG	Swan Island, Caribbean.
WSX	Boston, Mass.
WSY	New York, N. Y. (intercontinental).
WWO	Cleveland, Ohio.
WWQ	Bellefonte, Pa.
WWU	Newark, N. J.
WWX	Washington, D. C.
WDZA	Portland, Me.
WDZB	Bristol, Tenn.
WDZC	Floyd Bennett, N. Y.
WDZD	Greensboro, N. C.
WDZE	Allentown, Pa.
WDZF	Pulaski, Va.
WDZG	Jacks Creek, Tenn.
WDZH	Lynchburg, Va.
WDZI	Gordonsville, Va.
WDZJ	Florence, S. C.
WDZK	Grand Rapids, Mich.
WDZL	Joliet, Ill.
WDZM	Lansing, Mich.
WDZN	Macon, Ga.
WDZO	Meridian, Miss.
WDZP	Peoria, Ill.
WDZQ	Rochester, N. Y.
WDZR	Springfield, Ill.
WDZS	Smiths Grove, Ky.
WDZT	South Bend, Ind.

Call letters	Station
WDZU	Savannah, Ga.
WDZV	Sault Ste. Marie, Mich.
WDZW	Tampa, Fla.
WDZX	Utica, N. Y.
WDZY	Winder, Ga.
WDZZ	Norfolk, Va.
WEZA	Baltimore, Md.
WEZB	Daytona Beach, Fla.
WEZC	Burlington, Vt.
WEZD	Melbourne, Fla.
WEZE	Columbia, S. C.
WEZF	Philadelphia, Pa.
WEZG	Augusta, Ga.
WEZH	Tallahassee, Fla.
WEZI	Ft. Myers, Fla.
WEZJ	Cross City, Fla.
WEZK	Front Royal, Va.
WEZL	New York, N. Y.
WEZM	Caribou, Me.
WEZN	Williamsport, Pa.
WEZO	Cove Valley, Pa.
WEZP	Charleston, W. Va.
WEZQ	Elkins, W. Va.
WEZR	Dothan, Ala.
WEZS	Muscle Shoals, Ala.
WEZT	Orlando, Fla.
WEZU	Westfield, Mass.
WEZV	Dayton, Ohio.
WEZW	Providence, R. I.
WEZX	Indianapolis, Ind. (experimental).
WEZY	Saginaw, Mich.
WEZZ	Battle Creek, Mich.
WGZA	Muskegon, Mich.
WGZB	Houlton, Me.
WGZC	Evansville, Ind.
WGZE	Harvey, Ill.
WGZF	Albany, Ga.
WGZG	Montpelier, Vt.
WGZH	Wilkes-Barre, Pa.
WGZI	Blackstone, Va.
WWAB	Buffalo, N. Y.
WWAC	Nashville, Tenn.
WWAF	Miami, Fla.
WWAG	New Orleans, La. (domestic).
WWAH	Albany, N. Y.
WWAP	Pittsburgh, Pa.
WWAQ	Jackson, Miss.
WWAR	Smithville, Tenn.
WWAS	Cincinnati, Ohio
WWAT	Birmingham, Ala.
WWAU	Memphis, Tenn.
WWAV	Jacksonville, Fla.
WWAW	Charleston, S. C.
WWBC	Fort Wayne, Ind.
WWBF	Mobile, Ala.
WWBI	Raleigh, N. C.
WWHP	Harrisburg, Pa.
WWHQ	Youngstown, Ohio
WWHR	Millinockett, Me.
WWHS	Chattanooga, Tenn.
WWHT	Toledo, Ohio
WWHU	Detroit, Mich.
WWHV	Greenwood, Miss.
WWHW	Milroy, Ind.
WWHX	Hayesville, Ohio
WWHY	Archbold, Ohio
WWHZ	Effingham, Ill.
WWIA	Lone Rock, Wis.
WWIB	Traverse City, Mich.
WWIC	Hartford, Conn.
WWIE	Goshen, Ind.
WWIF	Elmira, N. Y.
WWIG	Louisville, Ky.
WWIH	Tylertown, Miss.
WWII	Atlanta, Ga.
WWIJ	Roanoke, Va.
WWIK	Erie, Pa.
WWIL	Indianapolis, Ind.
WWIM	Knoxville, Tenn.
WWIN	Adairsville, Ga.
WWIO	Alma, Ga.
WWIP	Anderson, S. C.
WWIQ	Brookville, Pa.
WWIR	Buckstown, Pa.
WWIS	Charlotte, N. C.
WWIT	Columbiaville, N. Y.
WWIU	Columbus, Ohio
WWIV	Dunkirk, N. Y.
WWIW	La Crosse, Wis.
WWIX	Crestview, Fla.
WWIY	Kirksville, Mo.
WWIZ	Knoxville, Mo.
WWJA	Lafayette, Ind.
WWJB	McCool, Ind.
WWJC	Mercer, Pa.
WWJD	Milwaukee, Wis.

Call letters	Station
WWJE	Monteagle, Tenn.
WWJF	Chesapeake, Ohio
WWJG	Spartanburg, S. C.
WWJH	Martinsburg, W. Va.
WWJI	New Hackensack, N. Y.
WWJJ	Perry, Ohio
WWJK	Putnam, Conn.
WWJL	Rockford, Ill.
WWJM	South Boston, Va.
WWJN	Greenville, S. C.
WWJO	Sunbury, Pa.
WWJP	Syracuse, N. Y.
WWJQ	Terre Haute, Ind.
WWJR	Vickery, Ohio
WWJS	Warren, Ohio
WWJT	Warsaw, Ky.
WWJU	Woodward, Pa.
WWJV	Cambridge, Ohio
WWJW	Akron, Ohio
WWJX	Augusta, Me.
WWJY	Bangor, Me.
WWJZ	Concord, N. H.

d. Radio call letters—alphabetically by stations.

Station	Call letters
Aberdeen, S. D	KEQX
Abilene, Tex	KCCQ
Acomita, N. M	KCBT
Adairsville, Ga	WWIN
Advance, Mo	KCDZ
Akron, Colo	KCEM
Akron, Ohio	WWJW
Albany, Ga	WGZF
Albany, N. Y	WWAH
Albuquerque, N. M	KCAF
Alexandria, Minn	KCDY
Allentown, Pa	WDZE
Alliance, Neb	KMZS
Alma, Ga	WWIO
Amarillo, Tex	KCAG
Anchorage, Alsk. (domestic)	KCDW
Anchorage, Alsk. (intercontinental)	KIS
Anderson, S. C	WWIP
Aniak, Alsk	KHDA
Anton Chico, N. M	KCCO
Archbold, Ohio	WWHY
Ardmore, Okla	KCCS
Arlington, Oreg	KEAL
Ashfork, Ariz	KCCJ
Atlanta, Ga	WWII
Atlantic, Ia	KCED
Auburn, Calif	KEAR
Augusta, Ga	WEZG
Augusta, Me	WWJX
Austin, Tex	KEAQ
Baker, Oreg	KEAS
Bakersfield, Calif	KEAT
Baltimore, Md	WEZA
Bangor, Me	WWJY
Battle Creek, Mich	WEZZ
Beaumont, Tex	KEQE
Belgrade, Mont	KCDI
Bellefonte, Pa	WWQ
Bellingham, Wash	KEQH
Beowawe, Nev	KCEF
Bethel, Alsk	KMZI
Big Delta, Alsk	KHDG
Big Spring, Tex	KCAP
Big Springs, Neb	KCEG
Billings, Mont	KCDK
Birmingham, Ala	WWAT
Bismarck, N. D	KCDV
Blackstone, Va	WGZI
Blanding, Utah	KEQN
Blue Canyon, Calif	KCEH
Blythe, Calif	KEAG
Boise, Ida	KCR
Boston, Mass	WSX
Brinkley, Ark	KEQD
Bristol, Tenn	WDZB
Brookville, Pa	WWIQ
Brookville, Tex	KEAU
Buckstown, Pa	WWIR
Buffalo, N. Y	WWAB
Buffalo Valley, Nev	KCEA
Burley, Ida	KCEI
Burlington, Ia	KCEJ
Burlington, Vt	WEZC
Butte, Mont	KCAG
Cambridge, Ohio	WWJV
Canton Island, Pac	KCCG
Caribou, Me	WEZM

Station	Call letters
Casper, Wyo	KEAE
Cassoday, Kan	KCBW
Chanute, Kan	KEOJ
Charleston, S. C	WWAW
Charleston, W. Va	WEZP
Charlotte, N. C	WWIS
Chattanooga, Tenn	WWHS
Chesapeake, Ohio	WWJF
Cheyenne, Wyo	KSG
Chicago, Ill	KDA
Cincinnati, Ohio	WWAS
Clarendon, Tex	KCCI
Cleveland, Ohio	WWO
Cochise, Ariz	KCCN
Coeur d'Alene, Ida	KCCX
Columbia, Mo	KCEB
Columbia, S. C	WEZE
Columbiaville, N. Y	WWIT
Columbus, Ohio	WWIU
Columbus, N. M	KCBY
Concord, N. H	WWJZ
Cordova, Alsk	KEOU
Corpus Christi, Tex	KEAW
Cove Valley, Pa	WEZO
Crestview, Fla	WWIX
Cross City, Fla	WEZJ
Custer, Mont	KCDL
Daggett, Calif	KCAX
Dallas, Tex	KEAJ
Dayton, Ohio	WEZV
Daytona Beach, Fla	WEZB
Delta, Utah	KEAX
Denver, Colo	KEAY
Des Moines, Ia	KCEN
Detroit, Mich	WWHU
Dickinson, N. D	KCDR
Dillon, Mont	KEAZ
Donner Summit, Calif	KCCL
Dothan, Ala	WEZR
Douglas, Wyo	KCDA
Drummond, Mont	KCDG
Dubois, Ida	KEOA
Duluth, Minn	KMZN
Dunkirk, N. Y	WWIV
Easton, Wash	KCEZ
Effingham, Ill	WWHZ

Station	Call letters
Elizabeth, N. J. (*See* Newark, N. J.)	WWU
Elkins, W. Va	WEZQ
Elko, Nev	KOJ
Ellensburg, Wash	KCCY
Elmira, N. Y	WWIF
El Morro, N. M	KCBZ
El Paso, Tex	KCAO
Engle, N. M	KEQZ
Enterprise, Utah	KEAH
Ephrata, Wash	KCCZ
Erie, Pa	WWIK
Eugene, Oreg	KEOB
Evansville, Ind	WGZC
Everett, Wash. (domestic)	KEQK
Everett, Wash. (intercontinental)	KCJ
Fairbanks, Alsk	KCDS
Farewell, Alsk	KHDF
Fargo, N. D	KCAN
Florence, S. C	WDZJ
Floyd Bennett, Long Island, N. Y	WDZC
Fort Bridger, Wyo	KCBX
Fort Jones, Calif	KEOZ
Fort Myers, Fla	WEZI
Fort Wayne, Ind	WWBC
Fort Worth, Tex	KKJ
Fort Worth, Tex. (central depot)	KCDB
French Frigate Shoals, Pac	KMZF
Fresno, Calif	KCU
Front Royal, Va	WEZK
Frontenac, Minn	KEQP
Gage, Okla	KEQA
Gainesville, Tex	KCEP
Galveston, Tex	KEOC
Garden City, Kan	KMZT
Golva, N. D	KCDQ
Gooding, Ida	KHDE
Gordonsville, Va	WDZI
Goshen, Ind	WWIE
Grand Forks, N. D	KCDD
Grand Island, Neb	KEAN
Grand Rapids, Mich	WDZK
Great Falls, Mont	KEOE
Greensboro, N. C	WDZD

Station	Call letters
Greenville, S. C	WWJN
Greenwood, Miss	WWHV
Guantánamo, Cuba	WFT
Gulkana, Alsk	KHDH
Haines, Alsk	KEQT
Harrisburg, Pa	WWHP
Hartford, Conn	WWIC
Harvey, Ill	WGZE
Hayes Center, Neb	KEQM
Hayesville, Ohio	WWHX
Helena, Mont	KCDH
Hilo, Hawaii, T. H	KMZA
Honolulu, Oahu, T. H. (domestic)	KHDJ
Honolulu, Oahu, T. H. (intercontinental)	KVM
Houlton, Me	WGZB
Houston, Tex	KCAU
Howland Island, Pa	KCCW
Humboldt, Nev	KCER
Huron, S. D	KEQG
Hutchinson, Kan	KMZK
Idaho Falls, Ida	KCAD
Indianapolis, Ind	WWIL
Indianapolis, Ind. (experimental)	WEZX
Indio, Calif	KEOF
Iowa City, Ia	KHDY
Jacks Creek, Tenn	WDZG
Jackson, Miss	WWAQ
Jacksonville, Fla	WWAV
Jamestown, N. D	KCDX
Jarvis Island, Pac	KMZE
Johnston Island, Pac	KMZC
Joliet, Ill	WDZL
Juneau, Alsk	KEAA
Kansas City, Mo	KRC
Kelso, Wash	KHDB
Kenai, Alsk	KHDK
Ketchikan, Alsk	KEQF
Key West, Fla	WBP
Kingman, Ariz	CKAH
Kirksville, Mo	WWIY
Knoxville, Mo	WWIZ
Knoxville, Tenn	WWIM
Kodiak, Alsk	KMZG

Station	Call letters
La Crosse, Wis	WWIW
Lafayette, Ind	WWJA
La Grande, Oreg	KCES
La Junta, Colo	KMZJ
Lake Charles, La	KEOY
Lake Minchumina, Alsk	KHDL
Lansing, Mich	WDZM
Laramie, Wyo	KCET
Las Vegas, Nev	KCS
Las Vegas, N. M	KEQB
Lebo, Kan	KCCV
Lewistown, Mont	KEAI
Lincoln, Neb	KHDC
Little Rock, Ark	KCAJ
Livermore, Calif	KCEU
Livingston, Mont	KCDJ
Locomotive Springs, Utah	KCCE
Lone Rock, Wis	WWIA
Long Beach, Calif	KEOH
Los Angles, Calif	KCT
Louisville, Ky	WWIG
Lynchburg, Va	WDZH
Macon, Ga	WDZN
Madison, Wis	KHDR
Maine, Ariz	KCBS
Makena, Maui, T. H	KMZR
Martinsburg, W. Va	WWJH
McCool, Ind	WWJB
McGrath, Alsk	KMZH
Medford, Oreg	KCX
Melbourne, Fla	WEZD
Memphis, Tenn	WWAU
Mercer, Pa	WWJC
Meridian, Miss	WDZO
Miami, Fla	WWAF
Midway Island, Pac	KCCM
Miles City, Mont	KCAZ
Milford, Utah	KCAT
Millinockett, Me	WWHR
Milroy, Ind	WWHW
Milwaukee, Wis	WWJD
Minneapolis, Minn	KCAQ
Minot, N. D	KCBV
Missoula, Mont	KCAY
Mobile, Ala	WWBF
Modesto, Calif	KEQC
Moline Ill	KCCU

Station	Call letters
Monroe, La	KMZP
Monteagle, Tenn	WWJE
Montezuma, Iowa	KCEV
Montpelier, Vt	WGZG
Moose Creek, Alsk	KHDI
Mormon Mesa, Nev	KEOK
Moses Point, Alsk	KMZZ
Mt. Shasta, Calif	KCEW
Mullan Pass, Mont	KEAM
Muscle Shoals, Ala	WEZS
Muskegon, Mich	WGZA
Naknek, Alsk	KMZY
Nashville, Tenn	WWAC
Navasota, Tex	KCDP
Needles, Calif	KEOL
Neosho, Mo	KCDC
Newark, N. J	WWU
New Florence, Mo	KCEX
New Hackensack, N. Y	WWJI
Newhall, Calif	KCCP
New Orleans, La. (domestic)	WWAG
New Orleans, La. (intercontinental)	WEK
New York, N. Y. (domestic)	WEZL
New York, N. Y. (intercontinental)	WSY
Nome, Alsk	KEQO
Norfolk, Va	WDZZ
Northdalles, Wash	KCEY
North Platte, Neb	KCEQ
Oakland, Calif	KCV
Oceanside, Calif	KCEO
Ogden, Utah	KMZU
Oklahoma City, Okla	KCCA
Omaha, Nebr	KJF
Ontario, Oreg	KEQJ
Orlando, Fla	WEZT
Otto, N. M	KCBU
Ottumwa, Iowa	KHDP
Overton, Nebr	KEOW
Palacios, Tex	KEOR
Palmdale, Calif	KCCD
Palmyra Island, Pac	KMZD

Station	Call letters
Parco, Wyo	KEOM
Pembina, N. D	KCDN
Pendleton, Oreg	KCDU
Peoria, Ill	WDZP
Perry, Ohio	WWJJ
Petersburg, Alsk	KEQV
Philadelphia, Pa	WEZF
Phoenix, Ariz	KCCB
Pittsburgh, Pa	WWAP
Plymouth, Utah	KEOI
Pocatello, Ida	KEAF
Port Allen, Kauai, T. H	KMZB
Portland, Oreg	KCY
Portland, Me	WDZA
Potrero Hills, Calif	KCCT
Providence, R. I	WEZW
Pueblo, Colo	KCAR
Pulaski, Va	WDZF
Putnam, Conn	WWJK
Raleigh, N. C	WWBI
Red Bluff, Calif	KEOV
Reno, Nev	KLK
Richmond, Va	WNR
Riverside, Calif	KEON
Roanoke, Va	WWIJ
Rochester, N. Y	WDZQ
Rochester, Minn	KEOQ
Rockford, Ill	WWJL
Rock Springs, Wyo	KDN
Rodeo, N. Mex	KCCF
Ruby, Alsk	KEQQ
Sacramento, Calif	KEOP
Saginaw, Mich	WEZY
St. Joseph, Mo	KHDV
St. Louis, Mo	KCQ
Salt Flat, Tex	KMZV
Salt Lake City, Utah	KGD
San Antonio, Tex	KCAW
San Diego, Calif	KEAO
San Francisco, Calif. (domestic)	KHDW
San Francisco, Calif. (intercontinental)	KSF
San Juan, P. R	WRW
Santo, Tex	KCCC
Sault Ste. Marie, Mich	WDZV

Station	Call letters
Savannah, Ga	WDZU
Seattle, Wash	KCZ
Seward, Alsk	KHDS
Sexton Summit, Oreg	KCEC
Sheridan, Wyo	KEOO
Shreveport, La	KCAK
Sidney, Neb	KCAB
Silver Lake, Calif	KEOG
Sioux City, Ia	KEOD
Sioux Falls, S. D	KEQI
Sitka, Alsk	KEQU
Smiths Grove, Ky	WDZS
Smithville, Tenn	WWAR
South Bend, Ind	WDZT
South Boston, Va	WWJM
Spartanburg, S. C	WWJG
Spokane, Wash	KCAS
Spring Bluff, Mo	KCDE
Springfield, Ill	WDZR
Springfield, Mo	KCAV
Stevenson, Wash	KCDM
Strevell, Ida	KME
Summit, Alsk	KEQR
Sunbury, Pa	WWJO
Superior, Mont	KCDF
Swan Island, Caribbean	WSG
Syracuse, N. Y	WWJP
Talkeetna, Alsk	KEQS
Tallahassee, Fla	WEZH
Tampa, Fla	WDZW
Tanana, Alsk	KHDT
Tanana Crossing, Alsk	KHDN
Terre Haute, Ind	WWJQ
Texarkana, Ark	KEAK
Tintic, Utah	KEOS
Toledo, Ohio	WWHT
Toledo, Wash	KEQL
Traverse City, Mich	WWIB
Trinidad, Colo	KEOX
Tucson, Ariz	KCAM
Tucumcari, N. Mex	KCAI
Tulsa, Okla	KCAA
Tyler, Tex	KEOT
Tylertown, Miss	WWIH
Upolu Point, T. H	KHDU
Utica, N. Y	WDZX
Valdez, Alsk	KHDM
Ventosa, Nev	KCEE
Vickery, Ohio	WWJR
Waco, Tex	KCDT
Wake Island, Pac	KEAD
Walla Walla, Wash	KHDQ
Wamsutter, Wyo	KCEK
Warren, Ohio	WWJS
Warsaw, Ky	WWJT
Washington, D. C	WWX
Watertown, S. D	KCDO
Wendover, Utah	KEAB
Westfield, Mass	WEZU
Whitehall, Mont	KEAP
Wichita, Kan	KCEL
Wichita Falls, Tex	KCCR
Wilkes-Barre, Pa	WGZH
Williams, Calif	KEAC
Williamsport, Pa	WEZN
Willmar, Minn	KCAL
Winder, Ga	WDZY
Wink, Tex	KCCH
Winslow, Ariz	KCAE
Woodward, Pa	WWJU
Yakima, Wash	KMZL
Yakutat, Alsk	KEQW
Yoakum, Tex	KEQY
Youngstown, Ohio	WWHQ

101. "Q" Signal abbreviations.—An asterisk (*) placed before the conventional Q signal denotes the signal is authorized for use in connection with transmissions by means of the communication facilities of the CAA.

All Q signals not preceded by an asterisk are authorized for use in communicating with aircraft operating in foreign air commerce but not approved for domestic use.

Abbreviation	*Question*	*Answer, advice, or order*
*QAA	At what time do you expect to arrive at . . . ?	I expect to arrive at . . . at . . . (o'clock).
*QAB	Are you making for . . . ?	I am making for . . . . or Make for . . . .
*QAC	Are you returning to . . . ?	I am returning to . . . . or Return to . . . .
*QAD	At what time did you leave . . . (place of departure)?	I left . . . (place of departure) at . . . (time).
*QAE	Have you news of . . . (call sign of the aircraft station)?	I have no news of . . . (call sign of the aircraft station).
*QAF	At what time did you pass . . . ?	I passed . . . at . . . (time).
*QAG	------------------------------	Arrange your flight in order to arrive at . . . (time) at . . . (place). or I am arranging my flight in order to arrive at . . . (time) at . . . (place).
*QAH	What is your height?	My height is . . . meters (or by any other way of stating it).
*QAI	Has any aircraft been signaled in my vicinity?	No aircraft has been signaled in your vicinity.
*QAJ	Shall I try to search for an aircraft in my vicinity (or by any other indication)? or Shall I try to search for aircraft . . . in my vicinity (or by any other indication)?	Try to search for an aircraft or aircraft in your vicinity (or by any other indication).
*QAK	Is another aircraft flying in my vicinity, involving a risk of collision? or Is aircraft . . . flying in my vicinity involving a risk of collision?	Beware of collision, other (one or more) aircraft is (are) flying in your vicinity. or Beware of collision, the aircraft indicated below (if particulars of such aircraft are known) is (or are) flying in your vicinity.
*QAL	Are you going to land at . . . ?	I am going to land at . . . . or Land at . . . .
*QAM	Can you give me the latest meteorological weather report for . . . (place of observation)?	Here is the latest meteorological weather report for . . . (place of observation).
*QAN	Can you give me the latest meteorological report concerning surface wind for . . . (place of observation)?	Here is the latest meteorological report concerning surface wind for . . . (place of observation).

Abbreviation	Question	Answer, advice, or order
*QAO	Can you give me the latest meteorological report concerning upper wind for . . . (place of observation)?	Here is the latest meteorological report concerning upper wind for . . . (place of observation).
*QAP	Shall I listen for you (or for . . .) on . . . kilocycles (or . . . meters)?	Listen for me (or for . . .) on . . . kilocycles (or . . . metres).
*QAQ	Am I in the vicinity of a prohibited area or of . . . prohibited area (name of the prohibited area)?	You are in the vicinity of a prohibited area or of . . . prohibited area (name of the prohibited area).
*QAR	May I stop listening on the watch wave for . . . minutes?	You may stop listening on the watch wave for . . . minutes.
*QAS	------------------------------	You are flying over a prohibited area or over . . . prohibited area (name of prohibited area).
*QAT	Shall I continue to send?	Listen before sending; you are interfering. or Listen before sending, you are sending at the same time as . . . .
*QAX	Have you in your aircraft the following person for whom I have a waiting radiotelegram (here follows the designation of the person as it appears in the address of the radiotelegram: name and qualifications)?	Yes, I have in my aircraft the person for whom you have a waiting radiotelegram.
*QAZ	Are you flying in a thunderstorm?	I am flying in a thunderstorm.
QBA	What is the visibility at . . . (place)?	Visibility at . . . (place) is . . . (meters).
QBB	What is the height of the cloud base at . . . (place)?	The height of the cloud base at . . . (place) is . . . (meters).
QBC	Can you transmit to me the meteorological observation at present made by you from the aircraft?	Here is the meteorological observation at present made by me from the aircraft.
QBE	------------------------------	I am about to wind in my aerial.
QBF	Are you flying in cloud?	QBF: I am flying in cloud, at a constant altitude. QBF (followed by figures): I am flying in cloud, at the altitude of . . . meters.
QBF		QBF ASC: I am flying in cloud and I am ascending. QBF (followed by figures) ASC: I am flying in cloud at the altitude of . . . meters and I am ascending.

Abbreviation	*Question*	*Answer, advice, or order*
		QBF ASC (followed by figures): I am flying in cloud and I am ascending towards the altitude of . . . meters.
		QBF (followed by figures) ASC (followed by figures): I am flying in cloud at the altitude of . . . meters and I am ascending towards the altitude of . . . meters.
		QBF DES: I am flying in cloud and I am descending.
		QBF (followed by figures) DES: I am flying in cloud at the altitude of . . . meters and I am descending.
		QBF DES (followed by figures): I am flying in cloud and I am descending towards the altitude of . . . meters.
		QBF (followed by figures) DES (followed by figures): I am flying in cloud at the altitude of . . . meters and I am descending towards the altitude of . . . meters.
QBG	Are you flying above cloud?	I am flying above cloud at the altitude of . . . m. or Fly above cloud at the altitude of . . . m.
QBH	Are you flying below cloud?	I am flying below cloud at the altitude of . . . m. or Fly below cloud at the altitude of . . . m.
QBI	------------------------------	The bad visibility regulations are in force.
QBJ	At what height is the upper limit of cloud?	The upper limit of cloud is at . . . meters.
QBM	Has . . . sent any message for me?	Here is the message sent by . . . at . . . (time).
QBN	Are you flying between two layers of cloud?	I am flying between two layers of cloud at the altitude of . . . m.
QBT	------------------------------	You are missing your dots.
QBU	Are you sure of the accuracy of telegram . . . ?	Telegram . . . is not clear.
QBW	Did you receive the telegram sent at . . . (time)?	The telegram sent at . . . (time) has not been received.

Abbreviation	*Question*	*Answer, advice, or order*
QCA	------------------------------	You are causing delay by your slowness in answering.
QCB	------------------------------	You are causing delay by answering out of your turn.
QCG	Shall I stand guard for you on the frequency of . . . kilocycles (wave length of . . . meters)?	Stand guard for me on the frequency of . . . kilocycles (wave length of . . . meters).
QCM	------------------------------	There seems to be a defect in your transmission.
QCP	------------------------------	Your note is bad.
QCS	------------------------------	My reception on long waves has broken down.
QCT	------------------------------	My reception on short waves has broken down.
QCY	------------------------------	I am working on trailing aerial. or Work on trailing aerial.
QDB	Have you sent telegram . . . to:	I could not send telegram . . . to . . . .
QDC	------------------------------	Telegram . . . has been sent by wire.
QDD	------------------------------	Telegram No. . . . has been refused by . . . as not in order. Please inform sender.
QDH	What is causing the present interference?	The present interference is caused by . . . .
QDK	------------------------------	Answer in the alphabetical order of the call signs.
QDL	Do you intend to ask me for a series of bearings?	I intend to ask you for a series of bearings.
QDM	What is the magnetic course to steer with no wind to make for you or for . . . ?	The magnetic course to steer with no wind to make for me or for . . . is . . . (degrees) at . . . (time).
QDO	Can you have transmitted by . . . station, on its working wave (or on the . . . wave), its call sign followed by a prolonged dash for . . . minutes, in order to permit me to use my aircraft D/F installation?	I am about to have transmitted by . . . station on its working wave (or on the . . . wave) its call sign followed by a prolonged dash for . . . minutes in order to permit you to use your aircraft D/F installation.
QDR	What is my magnetic bearing in relation to you or to . . . ?	Your magnetic bearing in relation to me or to . . . is . . . degrees . . . (time).
QDT	Are you flying in good horizontal visibility (more than 1,000 m)?	I am flying in good horizontal visibility (more than 1,000 m) at a height of . . . meters.
QDV		I am flying in a horizontal visibility of less than 1,000 m at a height of . . . meters.

Abbreviation	Question	Answer, advice, or order
QFA	Can you give me meteorological information on the section from . . . to . . . ?	I give you meteorological information on the section from . . . to . . . .
QFB	Are new meteorological observations requested?	New meteorological observations are requested.
QFC	Can you give me upper wind from . . . to . . . ?	I give you upper wind from . . . to . . . .
QFD	My altimeter was adjusted at . . . (aerodrome of departure) at . . . (time of departure with time standard employed, GMT, CET, etc.). Give me the altimeter correction for . . . (name of aerodrome or other place where the altimeter indication should be accurate). Example: QFD? Brussels 1030 CET Paris?	At . . . (name of aerodrome or other place where the altimeter indication should be accurate) . . . meters must be added to (subtracted from) the altimeter reading. Example: QFD Paris add 70 m.
QFE	Give me the present barometric pressure, not reduced to sea level and in mb, on the ground at . . . aerodrome (name of aerodrome). Example: QFE? Lyons?	The present barometric pressure, not reduced to sea level, on the ground at . . . aerodrome (name of aerodrome) is . . . (mb). Example: QFE Lyons 973.7.
QFF	Give me the present barometric pressure, reduced to sea level and in mb, on the ground at . . . aerodrome (name of aerodrome). Example: QFF? Marseilles?	The present barometric pressure reduced to sea level on the ground at . . . aerodrome (name of aerodrome) is . . . (mb). Example: QFF Marseilles 1015.
QFG	Am I over the aerodrome?	You are over the aerodrome.
QFH	May I descend below the clouds?	You may descend below the clouds.
QFI		Please light the aerodrome lights.
QFJ		The aerodrome lights are in operation.
QFK	Please send up maroons.	I will send up maroons.
QFL	Please send up pyrotechnic lights.	I will send up pyrotechnic lights.
QFM	At what height must I fly?	Fly at . . . m.
QFN		Please do not wind in aerial until end of work.
QFO	May I land direct?	You may land direct.
QFP		My navigation lights are not working.
QFQ		The landing lights are not working.
QFR	Is my undercarriage damaged?	Your undercarriage is damaged.
QFS	Put the radiobeacon at . . . in operation.	The radiobeacon at . . . will be in operation in . . . minutes.

Abbreviation	*Question*	*Answer, advice, or order*
QFT	Between what heights is the danger of ice formation signaled or forecast in the region of . . .?	QFT OBS: Ice formation observed between . . . and . . . m altitude above sea level in the region of . . . . QFT NIL: No ice formation between . . . and . . . m altitude above sea level in the region of . . . . QFT NON OBS: Observations are lacking in the region of . . . . QFT: Danger of ice formation between . . . and . . . m altitude above sea level in the region of . . . .
QFU	What is the prescribed direction for landing defined by the value of the magnetic course to be maintained in order to follow it?	The direction prescribed for landing defined by the value of the magnetic course to be maintained in order to follow it is . . . degrees.
QFV	Can you give me the direction of the line of landing lights (green, white, red)?	The direction of the line of landing lights (green, white, red) is . . . .
QFW	Is the line of landing lights (green, white, red) working?	The line of landing lights (green, white, red) is working.
		I am working (or am going to work) on an aerial with reduced radiation (fixed or partially wound in). or Work on an aerial with reduced radiation (fixed or partially wound in).
QFY	Please give me, in abbreviated international code, the latest meteorological report for . . . (place of observation or meteo sign of the observation station)?	Here is, in abbreviated international code, the latest meteorological report for (place of observation or meteo sign of the observation station).
QFZ	Please give me the weather forecast in the region of . . . (place of observation or meteo sign of the observation station)?	Here is the weather forecast in the region of . . . (place of observation or meteo sign of the observation station).
QGA	May I land immediately using the signals of the radiobeacon?	You may land immediately, using the signals of the radiobeacon.
QGB		You may not land at . . . using the radiobeacon procedure.
QGC	Can you direct my landing?	I cannot direct your landing. Remain outside controlled zone (zone of approach).
QGD	Are there on my track any obstacles of vertical extension exceeding my altitude, which is . . . m above sea level?	There are on your track obstacles . . . meters in height.

Abbreviation	Question	Answer, advice, or order
QGE	What is my position in relation to your station expressed in true bearing and distance?	Your position in relation to my station is given by true bearing . . . distance . . . km.
QGF	Can you give me my position in relation to your station or to . . . expressed by means of the magnetic course to be steered with no wind and the distance?	Your position in relation to my station or to . . . expressed by means of the magnetic course to be steered with no wind and the distance is . . . degrees, . . . km.
QGH	May I land using the procedure for coming down through cloud?	You may land using the procedure for coming down through cloud.
QGI		You may not land using the procedure for coming down through cloud.
QGJ		Reduce your communication to a strict minimum; I have to communicate with other aircraft.
QGK		Fly so that your true bearing in relation to . . . remains constant at . . . and at a height of . . . meters. or I am flying so that my true bearing in relation to . . . remains constant at . . . and at a height of . . . meters.
QGL	May I enter the controlled zone?	You may enter the controlled zone.
QGM		You may not enter the controlled zone. or Leave the controlled zone.
QGN	May I land at . . . ?	You may land at . . . .
QGO		You may not land at . . . .
QGP	What is my turn for landing?	Your turn for landing is . . . .
QGQ		Await orders and remain at the height of . . . meters in the vicinity of . . . .
QGR	May I land at . . . without making a left-hand circuit?	You may land at . . . without making a left-hand circuit.
QGS		You may not land without making a left-hand circuit.
QGT	------------------------------	Fly for . . . minutes in the opposite direction to that which you are following at present.
QGU	------------------------------	Fly for . . . minutes, keeping the magnetic course of . . . degrees.
QGV	Do you see me?	I see you at . . . (cardinal point of the direction).

Abbreviation	*Question*	*Answer, advice, or order*
QGX	May I land using the "ZZ" procedure.	You may land using the "ZZ" procedure.
QGY	----------------------------------	You may not land using the "ZZ" procedure.
*QRA	What is the name of your station?	The name of my station is . . . .
*QRB	How far approximately are you from my station?	The approximate distance between our stations is . . . nautical miles (or . . . kilometers).
*QRC	What company (or Government administration) settles the accounts for your station?	The accounts for my station are settled by the . . . company (or by the Government administration of . . .).
*QRD	Where are you bound and where are you from?	I am bound for . . . from . . . .
*QRG	Will you tell me my exact frequency (wave length) in kc (or m)?	Your exact frequency (wave length) is . . . kc (or . . . m).
*QRH	Does my frequency (wave length) vary?	Your frequency (wave length) varies.
*QRI	Is my note good?	Your note varies.
*QRJ	Do you receive me badly? Are my signals weak?	I cannot receive you. Your signals are too weak.
*QRK	Do you receive me well? Are my signals good?	I receive you well. Your signals are good.
*QRL	Are you busy?	I am busy (or I am busy with . . .). Please do not interfere.
*QRM	Are you being interfered with?	I am being interfered with.
*QRN	Are you troubled by atmospherics?	I am troubled by atmospherics.
*QRO	Shall I increase power?	Increase power.
*QRP	Shall I decrease power?	Decrease power.
*QRQ	Shall I send faster?	Send faster (. . . words per minute).
*QRS	Shall I send more slowly?	Send more slowly (. . . words per minute).
*QRT	Shall I stop sending?	Stop sending.
*QRU	Have you anything for me?	I have nothing for you.
*QRV	Are you ready?	I am ready.
*QRW	Shall I tell . . . that you are calling him on . . . kc (or . . . m)?	Please tell . . . that I am calling him on . . . kc (or . . . m).
*QRX	Shall I wait? When will you call me again?	Wait (or Wait until I have finished communicating with . . .). I will call you at . . . o'clock (or immediately).
*QRY	What is my turn?	Your turn is No. . . . (or according to any other method of arranging it).
*QRZ	Who is calling me?	You are being called by . . . .
*QSA	What is the strength of my signals (1 to 5)?	The strength of your signals is . . . (1 to 5).

Abbreviation	Question	Answer, advice, or order
*QSB	Does the strength of my signals vary?	The strength of your signals varies.
*QSD	Is my keying correct? Are my signals distinct?	Your keying is incorrect. Your signals are bad.
*QSG	Shall I send . . . telegrams (or one telegram) at a time?	Send . . . telegrams (or one telegram) at a time.
*QSJ	What is the charge per word for . . ., including your internal telegraph charge?	The charge per word for . . . is . . . francs, including my internal telegraph charge.
*QSK	Shall I continue with the transmission of all my traffic? I can hear you through my signals.	Continue with the transmission of all your traffic. I will interrupt you if necessary.
*QSL	Can you give me acknowledgment of receipt?	I give you acknowledgment of receipt.
*QSM	Shall I repeat the last telegram I sent you?	Repeat the last telegram you sent me.
*QSO	Can you communicate with . . . direct (or through the medium of . . .)?	I can communicate with . . . direct (or through the medium of . . .).
*QSP	Will you retransmit to . . . free of charge?	I will retransmit to . . . free of charge.
*QSR	Has the distress call received from . . . been cleared?	The distress call received from . . . has been cleared by . . . .
*QSU	Shall I send (or reply) on . . . kc (or . . . m) and/or on waves of type A_1, A_2, A_3, or B?	Send (or reply) on . . . kc (or . . . m) and/or on waves of type A_1, A_2, A_3, or B.
*QSV	Shall I send a series of VVV?	Send a series of VVV.
*QSW	Will you send on . . . kc (or . . . m) and/or on waves of type A_1, A_2, A_3, or B?	I am going to send on . . . kc (or . . . m) and/or on waves of type A_1, A_2, A_3, or B.
*QSX	Will you listen for . . . (call sign) on . . . kc (or . . . m)?	I am listening for . . . (call sign) on . . . kc (or . . . m).
*QSY	Shall I send on . . . kc (or . . . m) without changing the type of wave? or Shall I change to transmission on another wave?	Send on . . . kc (or . . . m) without changing the type of wave. or Change to transmission on another wave.
*QSZ	Shall I send each word or group twice?	Send each word or group twice.
*QTA	Shall I cancel telegram No. . . . as if it had not been sent?	Cancel telegram No. . . . as if it had not been sent.
*QTB	Do you agree with my number of words?	I do not agree with your number of words; I will repeat the first letter of each word and the first figure of each number.
*QTC	How many telegrams have you to send?	I have . . . telegrams for you (or for . . .).

Abbreviation	*Question*	*Answer, advice, or order*
QTE	What is my true bearing in relation to you? or What is my true bearing in relation to . . . (call sign)? or What is the true bearing of . . . (call sign) in relation to . . . (call sign)?	Your true bearing in relation to me is . . . degrees. or Your true bearing in relation to . . . (call sign) is . . . degrees at . . . (time). or The true bearing of . . . (call sign) in relation to . . . (call sign) is . . . degrees at . . . (time).
QTF	Will you give me the position of my station according to the bearings taken by the direction-finding stations which you control?	The position of your station according to the bearings taken by the direction-finding stations which I control is . . . latitude . . . longitude.
QTG	Will you send your call sign for 50 seconds followed by a dash of 10 seconds on . . . kc (or . . . m) in order that I may take your bearing?	QTG: I will send my call sign for 50 seconds, followed by a dash of 10 seconds, using ordinary signals (without impulsions), in order that you may take my bearing. QTG (followed by figures): I will send my call sign for 50 seconds, followed by a dash of 10 seconds, on . . . kc (or . . . m), using ordinary signals (without impulsions), in order that you may take my bearing. QTG IMP: I will send my call sign for 50 seconds, followed by a dash of 10 seconds, using signals emitted with impulsions, in order that you may take my bearing. QTG (followed by figures) IMP: I will send my call sign for 50 seconds, followed by a dash of 10 seconds, on . . . kc (or . . . m), using signals emitted by impulsions, in order that you may take my bearing. QTG IMP (followed by figures): I will send my call sign for 50 seconds, followed by a dash of 10 seconds, using signals emitted by impulsions, at the rate of . . . impulsions per second, in order that you may take my bearing.

Abbreviation	*Question*	*Answer, advice, or order*
		QTG (followed by figures) IMP (followed by figures): I will send my call sign for 50 seconds, followed by a dash of 10 seconds, on . . . kc (or . . . m), using signals emitted by impulsions, at the rate of . . . impulsions per second, in order that you may take my bearing.
QTH	What is your position in latitude and longitude (or by any other way of showing it)?	My position is . . . latitude . . . longitude (or by any other way of showing it).
QTI	What is the angle comprised between the longitudinal axis of your aircraft and the direction of geographical North?	The angle comprised between the longitudinal axis of my aircraft and the direction of geographical North is . . . degrees.
QTI SOL	What is the angle comprised between the track effectively followed by your aircraft and the direction of geographical North?	The angle comprised between the route effectively followed by my aircraft and the direction of geographical North is . . . degrees.
QTJ	What is your speed?	My speed is . . . knots (or . . . kilometers) per hour.
QTM	Send radioelectric signals and submarine sound signals to enable me to fix my bearing and my distance.	I will send radioelectric signals and submarine sound signals to enable you to fix your bearing and your distance.
QTO	Have you left dock (or port)?	I have just left dock (or port).
QTP	Are you going to enter dock (or port)?	I am going to enter dock (or port).
QTQ	Can you communicate with my station by means of the International Code of Signals?	I am going to communicate with your station by means of the International Code of Signals.
*QTR	What is the exact time?	The exact time is . . . .
QTU	What are the hours during which your station is open?	My station is open from . . . to . . . .
QUA	Have you news of . . . (call sign of the mobile station)?	Here is news of . . . (call sign of the mobile station).
QUB	Can you give me in this order information concerning visibility, height of clouds, ground wind for . . . (place of observation)?	Here is the information requested: . . . .
QUC	What is the last message received by you from . . . (call sign of the mobile station)?	The last message received by me from . . . (call sign of the mobile station) is . . . .
QUD	Have you received the urgency signal sent by . . . (call sign of the mobile station)?	I have received the urgency signal sent by . . . (call sign of the mobile station) at . . . (time).

Abbreviation	Question	Answer, advice, or order
QUF	Have you received the distress signal sent by . . . (call sign of the mobile station)?	I have received the distress signal sent by . . . (call sign of the mobile station) at . . . (time).
QUG	Are you being forced to alight in the sea (or to land)?	I am forced to alight (or land) at . . . (place).
QUH	Will you indicate the present barometric pressure at sea level?	The present barometric pressure at sea level is . . . (units).
QUJ	Will you indicate the true course for me to steer with no wind to make for you? or Will you indicate the true course for me to steer to make for you or for . . . ?	The true course for you to steer with no wind to make for me is . . . (degrees) at . . . (time). or The true course for you to steer to make for me or for . . . is . . . (degrees) at . . . (time).
*QXA	Please connect reperforator to this circuit.	Reperforator connected to your circuit.
*QXB	What is . . . (call letters) current (SPECIAL) weather?	SPL (followed by SPECIAL weather report) (preceded by 10 bell signal).
*QXC	Latest . . . (ceiling, barometer or visibility, etc.) from . . . (station) appears incorrect. Can you verify from origin?	Here follows verification from origin of . . . (questioned item) from . . . (station).
*QXD	Will you please relay . . . (weather, forecast, sequence) from . . . (station, circuit)? NOTE.—Request will cover a single instance of relay.	Please discontinue relaying . . . . NOTE.—Messages will be sent if more than one instance of relaying is needed, such as request for routine or scheduled relaying. Record time and date of QXD on messages that request relays.
*QXE	What range (of printer operation) do you get from . . . (station)?	I get a range (of printer operation) of . . . (points) to . . . (points) from . . . (station).
*QXF	What was the last message sent by you to . . . (station)?	The last message sent by me to . . . (station) was . . . .
*QXG	Shall I recheck my message number . . . ? How many words do you get?	Please recheck your message number . . . . I get . . . words.
*QXH	Shall I correct your message number . . . check . . . to read . . . ?	Please correct my message number . . . check . . . to read . . . .
*QXI	What is your local range (of printer operation)?	My local range (of printer operation) is from . . . (points) to . . . (points).
*QXJ	What was address and time of transmission of your message number . . . ?	My message number . . . was addressed . . . and was . . . transmitted . . . (time).

Abbreviation	*Question*	*Answer, advice, or order*
*QXK	Please repeat . . . (or in . . . please repeat . . . to . . .) (any desired transmission or portion thereof)?	Please get . . . (call letters) telephone test room in on this line to clear trouble.
*QXM	Does the garbled transmission appear to be due to local trouble at my station? Shall I change my . . . (printer, transmitter, perforator, reperforator)?	The garbling appears to be due to local trouble at your station. Please change your . . . (printer transmitter, perforator, reperforator). A. Your transmission is garbling occasionally. B. Your transmission is garbling frequently. Readable with difficulty. C. Your transmission is garbling badly. Nothing readable. D. The line was running open, or was open from . . . to . . . (time). E. Carriage return impulses are missing from your transmission. F. Line feed impulses are missing from transmission.
*QXN	Can you repeat . . . (call letters) last transmission to me? He is garbling and unreadable.	Here is last . . . (call letters) transmission to you.
*QXO	Has reception at your station been interrupted? (Add QYG? . . .).	Reception at this station has been interrupted. (Add QYG . . .).
*QXP	Was the transmission garbled on the circuit from which it has been transferred? Will you correct as soon as possible?	The transmission was garbled on the circuit from which it has been transferred. Corrections will be obtained and forwarded as soon as possible.
*QXQ	Can you advise whereabouts of . . . (name, or title, as Communication Supervisor, Mechanician, or other employee)?	. . . (name or title) is at . . . (place) or is expected at . . . (place) at . . . (time).
*QYA	Please use simultaneous keying on . . . (frequency) and . . . (frequency)?	I shall now key simultaneously on . . . (frequency) and . . . (frequency).
*QYB	Shall I send RY for . . . (seconds)?	Send RY for . . . (seconds).
*QYC	What is present field condition at . . . (call letters)?	Field conditions at . . . (call letters) are . . . (good; or describe conditions briefly).
*QYD		A. Teletype reception will be interrupted at . . . (station) until further notice.

Abbreviation	Question	Answer, advice, or order
		B. Teletype reception resumed at . . . (station) at . . . (time).
*QYE	How many gallons of aviation gasoline are now available at . . . (station)?	. . . gallons of aviation gasoline are now available at . . . (station).
*QYF	How many gallons of aircraft lubricating oil are now available at . . . (station)?	. . . gallons of aircraft lubricating oil are now available at . . . (station).
*QYG	What is the last message received by you from . . . (station)?	The last message received by me from . . . (station) is . . . .

APPENDIX I

METEOROLOGICAL CONSTANTS AND CONVERSION FORMULAS

1. Astronomical constants.

Distance of earth from sun at aphelion	94,400,000 miles.
Distance of earth from sun at perihelion	91,400,000 miles.
Distance of earth from sun (mean)	92,900,000 miles.
Distance of moon from earth (mean)	238,857 miles.
Diameter of earth (equatorial)	7,927 miles.
Diameter of earth (polar)	7,900 miles.
Diameter of earth (mean)	7,913 miles.
Diameter of moon	2,160 miles.
Diameter of sun	864,400 miles.
Velocity of light (in a vacuum)	2.99796×10^{10} cm/sec. 186,284 miles/sec.
Angular velocity of the earth's rotation (ω)	$\frac{2\pi}{86164}$ radians/sec.

2. Density.

Dry air with normal content CO_2 (3 volumes CO_2 per 10,000 of air) at 760 mm pressure, and 0° C. temperature	0.0012930 gm/cm.^{3}
Dry air, free from CO_2, at 760 mm pressure, and 0° C. temperature	0.0012928 gm/cm.^{3}
Mercury (Hg) 0° C	13.595 gm/cm.^{3}

3. Gravity.

Standard acceleration due to gravity	9806.65 cm/sec/sec. 32.1740 ft/sec/sec.

4. Heat.

Latent heat of fusion of ice	79.7 cal/gm.
Latent heat of vaporization of water at 100° C	539.1 cal/gm.
at 0° C	594.9 cal/gm.
Specific heat of air: Constant pressure (C_p)	0.2396 cal/gm.
Constant volume (C_v)	0.1707 cal/gm.
C_p/C_v	1.403.

Specific heat of ice (0° C.) .... 0.487.
Specific heat of water (15° C.) .... 1.0000.
Gas constants:
Universal gas content (R) ... 8.317×10^7 ergs/°C./g mole.
8.317 Joules/°C./g mole.
Specific gas constant for dry air:
Units: Millibars, kg/m³, °Abs. (C.) ..... 2.8703.
Dynes/cm², gm/cm³, °Abs. (C.) .... 2.8703×10^6.
cm of Hg, kg/m³, °Abs. (C.) .... 0.215.
in. of Hg, lb/ft³, °Abs. (F.) .... 0.751.
1 gram-calorie ... 4.18×10^7 ergs = 4.18 Joules.
1 watt .... 1 Joule/sec = 10^7 ergs/sec = 14.32 cal/min.

5. Radiation.

Solar constant .... 1.94 cal/cm²/min (±2%).
Stefan's constant (σ) .... 5.709×10^{-5} ergs/cm²/sec.
82×10^{-12} cal/cm²/min.

6. Temperature.

Absolute zero	0° A_c	−273° C.	−459.4° F.
Ethyl alcohol melts		−130° C.	
Mercury melts		−39° C.	
Ice melts	273° A_c	0° C.	32° F.
Water boils	373° A_c	100° C.	212° F.

(All of the above at 760 mm pressure)

7. Beaufort scale of wind velocities.

Beaufort No.	Description of wind	Velocity	
		Statute miles per hour	Meters per second
0	Calm	Less than 1	Less than 0.4
1	Light air	1 to 3	0.4 to 1.5
2	Light breeze	4 to 7	1.6 to 3.3
3	Gentle breeze	8 to 12	3.4 to 5.4
4	Moderate breeze	13 to 18	5.5 to 7.9
5	Fresh breeze	19 to 24	8.0 to 10.7
6	Strong breeze	25 to 31	10.8 to 13.8
7	Moderate gale	32 to 38	13.9 to 17.1
8	Fresh gale	39 to 46	17.2 to 20.7
9	Strong gale	47 to 54	20.8 to 24.4
10	Whole gale	55 to 63	24.5 to 28.4
11	Storm	64 to 75	28.5 to 33.5
12	Hurricane	Above 75	Above 33.5

8. Pressure of aqueous vapor over water (dynamic measures).

Temperature (°C.)	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
	mb.	mb.	mb.	mb.	mb.	mb.	mb.	mb.	mb.	mb.
0	6.11	6.15	6.20	6.24	6.29	6.33	6.38	6.42	6.47	6.52
1	6.56	6.61	6.66	6.71	6.76	6.81	6.86	6.90	6.95	7.00
2	7.05	7.10	7.16	7.21	7.26	7.31	7.36	7.42	7.47	7.52
3	7.58	7.63	7.68	7.74	7.79	7.85	7.90	7.96	8.02	8.07
4	8.13	8.19	8.25	8.30	8.36	8.42	8.48	8.54	8.60	8.66
5	8.72	8.78	8.84	8.91	8.97	9.03	9.09	9.16	9.22	9.28
6	9.35	9.41	9.48	9.54	9.61	9.68	9.74	9.81	9.88	9.95
7	10.02	10.09	10.16	10.22	10.30	10.37	10.44	10.51	10.58	10.65
8	10.73	10.80	10.87	10.95	11.02	11.10	11.17	11.25	11.32	11.40
9	11.48	11.56	11.64	11.71	11.79	11.87	11.95	12.03	12.12	12.20
10	12.28	12.36	12.44	12.53	12.61	12.70	12.78	12.87	12.95	13.04
11	13.13	13.21	13.30	13.39	13.48	13.57	13.66	13.75	13.84	13.93
12	14.03	14.12	14.21	14.31	14.40	14.50	14.59	14.69	14.78	14.88
13	14.98	15.08	15.18	15.28	15.38	15.48	15.58	15.68	15.78	15.89
14	15.99	16.09	16.20	16.30	16.41	16.51	16.62	16.73	16.84	16.95
15	17.06	17.17	17.28	17.39	17.50	17.61	17.73	17.84	17.96	18.07
16	18.19	18.30	18.42	18.54	18.66	18.78	18.90	19.02	19.14	19.26
17	19.38	19.51	19.63	19.76	19.88	20.01	20.13	20.26	20.39	20.52
18	20.65	20.78	20.91	21.04	21.17	21.31	21.44	21.58	21.71	21.85
19	21.98	22.12	22.26	22.40	22.54	22.68	22.82	22.96	23.11	23.25
20	23.40	23.54	23.69	23.83	23.98	24.13	24.28	24.43	24.58	24.73
21	24.88	25.04	25.19	25.35	25.50	25.66	25.82	25.98	26.14	26.30
22	26.46	26.62	26.78	26.94	27.11	27.27	27.44	27.61	27.78	27.94
23	28.11	28.28	28.46	28.63	28.80	28.98	29.15	29.33	29.51	29.68
24	29.86	30.04	30.22	30.40	30.59	30.77	30.96	31.14	31.33	31.51
25	31.70	31.89	32.08	32.28	32.47	32.66	32.86	33.05	33.25	33.45
26	33.64	33.84	34.04	34.25	34.45	34.65	34.86	35.06	35.27	35.48
27	35.69	35.90	36.11	36.32	36.53	36.75	36.96	37.18	37.40	37.62
28	37.84	38.06	38.28	38.50	38.73	38.95	39.18	39.41	39.64	39.87
29	40.10	40.33	40.56	40.80	41.04	41.27	41.51	41.75	41.99	42.23
30	42.48	42.72	42.97	43.21	43.46	43.71	43.96	44.21	44.47	44.72
31	44.98	45.23	45.49	45.75	46.01	46.27	46.54	46.80	47.07	47.33
32	47.60	47.87	48.14	48.42	48.69	48.97	49.24	49.52	49.80	50.08
33	50.36	50.65	50.93	51.22	51.50	51.79	52.08	52.37	52.67	52.96
34	53.26	53.56	53.85	54.15	54.46	54.76	55.06	55.37	55.68	55.99
35	56.30	56.61	56.92	57.24	57.56	57.87	58.19	58.51	58.84	59.16
36	59.49	59.81	60.14	60.47	60.81	61.14	61.47	61.81	62.15	62.49
37	62.83	63.17	63.52	63.86	64.21	64.56	64.91	65.27	65.62	65.98
38	66.34	66.69	67.06	67.42	67.78	68.15	68.52	68.89	69.26	69.63
39	70.01	70.38	70.76	71.14	71.53	71.91	72.30	72.68	73.07	73.46
40	73.86	74.25	74.65	75.04	75.44	75.85	76.25	76.66	77.06	77.47
41	77.88	78.30	78.71	79.13	79.55	79.97	80.39	80.81	81.24	81.67
42	82.10	82.53	82.97	83.40	83.84	84.28	84.72	85.17	85.61	86.06
43	86.51	86.96	87.42	87.87	88.33	88.79	89.26	89.72	90.19	90.66
44	91.13	91.60	92.07	92.55	93.03	93.51	93.99	94.48	94.97	95.46

9. Pressure of aqueous vapor over ice (dynamic measures).

Temperature (° C.)	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
	mb.	*mb.*	*mb.*	*mb.*	*mb.*	*mb.*	*mb.*	*mb.*	*mb.*	*mb.*
35	0.225	0.222	0.220	0.218	0.215	0.213	0.211	0.208	0.206	0.20[illegible]
34	.251	.248	.245	.243	.240	.237	.235	.232	.230	.22[illegible]
33	.279	.276	.273	.270	.267	.265	.262	.259	.256	.25[illegible]
32	.311	.307	.304	.301	.298	.295	.291	.288	.285	.28[illegible]
31	.345	.342	.338	.335	.331	.328	.324	.321	.317	.31[illegible]
30	.384	.380	.376	.372	.368	.364	.360	.357	.353	.349
29	.426	.421	.417	.413	.408	.404	.400	.396	.392	.389
28	.472	.467	.462	.458	.453	.448	.444	.439	.435	.430
27	.523	.518	.512	.507	.502	.497	.492	.487	.482	.477
26	.579	.573	.567	.561	.556	.550	.545	.539	.534	.528
25	.640	.634	.627	.621	.615	.609	.602	.596	.590	.585
24	.707	.700	.693	.686	.679	.673	.666	.659	.653	.646
23	.780	.773	.765	.758	.750	.743	.736	.728	.721	.714
22	.861	.852	.844	.836	.828	.820	.812	.804	.796	.788
21	.949	.939	.930	.921	.912	.904	.895	.886	.878	.869
20	1.04	1.03	1.02	1.01	1.00	1.00	.986	.976	.967	.958
19	1.15	1.14	1.13	1.12	1.11	1.10	1.09	1.07	1.06	1.05
18	1.26	1.25	1.24	1.23	1.22	1.20	1.19	1.18	1.17	1.16
17	1.39	1.37	1.36	1.35	1.34	1.32	1.31	1.30	1.29	1.27
16	1.52	1.51	1.49	1.48	1.47	1.45	1.44	1.43	1.41	1.40
15	1.67	1.65	1.64	1.62	1.61	1.59	1.58	1.57	1.55	1.54
14	1.83	1.81	1.80	1.78	1.76	1.75	1.73	1.72	1.70	1.69
13	2.00	1.99	1.97	1.95	1.93	1.92	1.90	1.88	1.86	1.85
12	2.19	2.17	2.15	2.13	2.12	2.10	2.08	2.06	2.04	2.02
11	2.40	2.38	2.35	2.33	2.31	2.29	2.27	2.25	2.23	2.21
10	2.62	2.60	2.57	2.55	2.53	2.51	2.48	2.46	2.44	2.42
9	2.86	2.83	2.81	2.78	2.76	2.74	2.71	2.69	2.67	2.64
8	3.12	3.09	3.07	3.04	3.01	2.99	2.96	2.93	2.91	2.88
7	3.40	3.37	3.34	3.31	3.29	3.26	3.23	3.20	3.17	3.15
6	3.70	3.67	3.64	3.61	3.58	3.55	3.52	3.49	3.46	3.43
5	4.03	4.00	3.97	3.93	3.90	3.87	3.83	3.80	3.77	3.74
4	4.39	4.35	4.31	4.28	4.24	4.21	4.17	4.14	4.10	4.07
3	4.77	4.73	4.69	4.65	4.61	4.58	4.54	4.50	4.46	4.42
2	5.18	5.14	5.10	5.06	5.01	4.97	4.93	4.89	4.85	4.81
1	5.63	5.58	5.53	5.49	5.44	5.40	5.36	5.31	5.27	5.23
0	6.11	6.06	6.01	5.96	5.91	5.86	5.81	5.77	5.72	5.67

10. Table of conventional symbols for common meteorological terms and mathematical expressions for certain terms.

C_p — Specific heat of dry air at constant pressure

C_v — Specific heat of dry air at constant volume

e — Vapor pressure (may be expressed in various units)

e_m — Saturated vapor pressure (may be expressed in various units)

f —Relative humidity in percent $=\frac{e}{e_m}.100$

L —Latent heat of vaporization of water

P —Pressure

P_d —Partial pressure of dry air

q —Specific humidity in grams of water vapor per gram of air—$0.625\frac{em}{p}\frac{f}{100}$

Q —Specific humidity in grams of water vapor per kilogram of air

R —Gas constant

T —Temperature

w —Mixing ratio in grams of water vapor per gram of dry air—$0.622\frac{em}{P_d}\frac{f}{100}$

W —Mixing ratio in grams of water vapor per kilogram of dry air

β —Temperature lapse rate (used by some authorities)

γ —Ratio of specific heat of dry air at constant pressure to specific heat at constant volume

Γ —Dry adiabatic lapse rate

θ —Potential temperature (usually expressed in degrees absolute)$=\frac{T}{\left(\frac{P}{1000}\right)^{0.288}}$

θ_d —Potential temperature of dry air (usually expressed in degrees absolute)$=\frac{T}{\left(\frac{Pd}{1000}\right)^{0.288}}$

θ_e —Equivalent potential temperature (usually expressed in degrees absolute)$=\theta_d e^{\frac{LW}{C_pT}}$

κ —Coefficient of the molecular conduction of heat

λ —Temperature lapse rate (also used as a symbol for wavelength)

μ —Micron

ν —Frequency of electromagnetic waves (also used as a symbol for the kinematic coefficient of viscosity)

ρ —Density

σ —Stefan's constant

ω —Angular velocity of the earth's rotation

11. Conversion formulas.—*a. Units of length.*

Units	Inches	Feet	Yards	Rods	Miles	Centimeters	Meters
1 inch	1	0. 08333	0. 02777	0. 005050	0. 000015	2. 540	0. 025400
1 foot	12	1	0. 33333	0. 060606	0. 000189	30. 480	0. 304800
1 yard	36	3	1	0. 181818	0. 000568	91. 440	0. 914401
1 rod	198	16. 5	5. 5	1	0. 003125	502. 921	5. 029210
1 mile	63360	5280	1760	320	1	160934. 72	1609. 3472
1 cm	0. 3937	0. 032808	0. 010936	0. 001988	0. 000006	1	0. 01
1 meter	39. 37	3. 280833	1. 093611	0. 198838	0. 000621	100	1

b. Units of mass (greater than avoirdupois ounces).

Units	Avoirdupois ounces	Avoirdupois pounds	Short tons	Long tons	Kilograms	Metric tons
1 av. ounce	1	0. 0625	0. 00003125	0. 000027901	0. 02835	0. 00002835
1 av. lb	16	1	0. 0005	0. 0004464	0. 453592	0. 00045359
1 short ton	32000	2000	1	0. 892857	907. 185	0. 907185
1 long ton	35840	2240	1. 12	1	1016. 047	1. 016047
1 kilogram	35. 273957	2. 2046	0. 0011023	0. 00009842	1	0. 0001
1 Met. ton	35273. 957	2204. 622	1. 1023112	0. 9842064	1000	1

c. Units of mass (less than pounds or kilograms).

Units	Grains	Avoirdupois drams	Apothecaries' drams	Avoirdupois ounces	Apothecaries ounces
1 grain	1	0. 036571	0. 016667	0. 002286	0. 00208333
1 dram av	27. 34375	1	0. 455729	0. 0625	0. 056966
1 dram ap	60	2. 194286	1	0. 137143	0. 125
1 ounce av	437. 5	16	7. 29166	1	0. 91146
1 ounce ap	480	17. 55428	8	1. 097143	1
1 pound av	7000	256	116. 667	16	14. 5833
1 pound ap	5760	210. 6514	96	13. 1657	12
1 gram	15. 432356	0. 564383	0. 257206	0. 035274	0. 032151
1 kilogram	15432. 356	564. 3833	257. 206	35. 274	32. 151

d. Units of mass (less than pounds or kilograms).

Units	Avoirdupois pounds	Apothecaries' pounds	Grams	Kilograms
1 grain	0. 000142857	0. 000173611	0. 0647989	0. 000064798
1 dram av	. 003906	. 0047472	1. 771845	. 0017718
1 dram ap	. 009571	. 010417	3. 887935	. 0038879
1 ounce av	. 0625	. 075955	28. 34953	. 02834953
1 ounce ap	. 068571	. 083333	31. 10348	. 03110348
1 pound av	1	1. 215278	453. 5924	. 45359
1 pound ap	. 82286	1	373. 2417	. 373242
1 gram	. 00220462	. 00267923	1	. 001
1 kilogram	2. 20462	2. 67923	1, 000	1

12. Units of pressure.

Standard atmosphere	760 mm mercury; 29.92 in. mercury; 1013.25 millibars; 14.696 lbs./ft.^{2}
1 millibar	1,000 dynes/cm.^{2}
1 millibar	0.0295299 in. mercury.
1 millibar	0.7500615 mm mercury.
1 in. mercury	33.86395 millibars.
1 in. mercury	25.40005 mm mercury.
1 mm mercury	1.33322387 millibars.
1 mm mercury	0.0393700 in. mercury.

13. Units of temperature.

Degrees absolute (° A.)	° C.+273.
Degrees centigrade (° C.)	° Abs.−273.
Degrees centigrade (° C.)	(° F.−32)5/9
Degrees Fahrenheit (° F.)	(° C.9/5)+32.

14. Units of velocity.

1 meter per second	2.237 miles per hour; 196.85 feet per minute.
1 mile per hour	0.447 meters per second.

Appendix II

GLOSSARY OF METEOROLOGICAL TERMS

Absolute humidity.—Mass of water present in a unit volume of air.

Absolute temperature.—A point on a temperature scale whose zero point lies at absolute zero (−273° C.).

Adiabatic.—A physical process which involves neither gain nor loss of heat. Opposed to isothermal.

Advection.—The horizontal transport of air.

Air mass.—A body of air which approximates horizontal uniformity in its properties.

Albedo.—The diffuse reflecting power of a body.

Altimeter.—A sensitive aneroid-type barometer used to measure heights.

Altocumulus.—An intermediate cloud type occurring in a layer or in patches, consisting of laminae or rather flattened globular masses.

Altostratus.—An intermediate cloud type occurring in a striated or fibrous veil, more or less gray or bluish in color.

Anabatic.—A term occasionally applied to an upslope wind.

Anallobar.—A closed isallobar encircling an area of maximum pressure rises.

Anemogram.—The record of wind velocity as recorded by an anemograph.

Anemograph.—An instrument designed to *record* the wind velocity.

Anemometer.—An instrument designed to *measure* the wind velocity.

Anemoscope.—An instrument designed to *indicate* the wind velocity.

Aneroid barometer.—A pressure measuring instrument which employs one or more partially evacuated metal cells to measure changes in the existing pressure.

Anticyclogenesis.—The meteorological process or processes which lead to the intensification of an anticyclone.

Anticyclolysis.—The meteorological process or processes which lead to the weakening of an anticyclone.

Anticyclone.—An atmospheric pressure system characterized by relatively high pressure at its center. Characterized by clockwise winds in the northern hemisphere and counterclockwise winds in the southern hemisphere.

Antitrades.—The winds which lie above the trade winds and blow from the opposite direction (southwest in the northern hemisphere, and northwest in the southern hemisphere).

Antitriptic.—A type of wind in which the existing pressure gradient is balanced mainly by friction.

Anvil cloud.—A cumulus or cumulonimbus cloud which has encountered a temperature inversion and has spread out laterally.

Aphelion.—The point in a planet's orbit which is farthest from the sun. For the earth this occurs on July 1.

Aurora.—An electrical atmospheric phenomenon consisting of bands or curtains of variously colored light radiating from the earth's magnetic poles. Called aurora borealis in the northern hemisphere, and aurora australis in the southern hemisphere. Same as northern lights of the northern hemisphere.

Autumn.—The season of the year between summer and winter. Usually considered to consist of the months, September, October and November. Also reckoned astronomically as extending from the autumnal equinox (Sept. 23) to the winter solstice (Dec. 22).

Autumnal equinox.—The point between the summer solstice and the winter solstice at which the sun crosses the equator. Occurs on September 23 in the northern hemisphere and on March 21 in the southern hemisphere. Day and night are of equal length on this date.

Back (wind).—A counterclockwise shift in the wind direction.

Baguio.—A local Philippine name for a tropical cyclone.

Banner cloud.—A cloud carried out by the wind as it blows past a mountain peak, having the appearance of a flag or a banner.

Bar.—A unit of pressure equal to 1 million dynes per square centimeter or 1,000 millibars.

Barogram.—The record of atmospheric pressure as recorded by a barograph.

Barograph.—An instrument designed to record the atmospheric pressure.

Barometer.—An instrument designed to measure and indicate the atmospheric pressure.

Beaufort.—A widely used scale of wind velocities.

Blizzard.—A widespread and long continued snow storm, usually accompanied by strong winds.

Bologram.—A record of solar radiation intensities at various wavelengths.

Bora.—A strong, cold, north wind of the gravity type blowing down across Greece from the uplands of the Balkan region.

Boyle's law.—At a constant temperature, the volume of a given quantity of any gas varies inversely as the pressure to which the gas is subjected.

Breeze.—A term of wind velocity as employed in the Beaufort wind scale.

Brickfelder.—A hot, cyclonic type wind of Australia.

Buys-Ballot's law.—If a person in the northern hemisphere stands with his back to the wind, the lower atmospheric pressure will be to his left. In the southern hemisphere the lower pressure will be to his right.

Calorie.—The quantity of heat required to raise the temperature of 1 gram of water 1° C. This is a small calorie or gram calorie. The large calorie or kilogram calorie is equal to 1,000 small calories. Usually the temperature change is understood to take place at 4° C., that is, from 3.5° C. to 4.5° C. If the temperature change involved is from 14.5° C. to 15.5° C., the resulting unit is called the *normal* calorie. The *mean* calorie is 1/100 the amount of heat necessary to raise the temperature of 1 gram of water from 0° C. to 100° C.

Celsius.—The inventor of the centigrade temperature scale. Used occasionally as the name of this scale.

Ceiling.—Used with at least two meanings in aviation.

a. The height above the ground of the lowest broken or overcast cloud layer.

b. The greatest elevation to which an airplane can climb.

Centigrade.—A widely used temperature scale in which the zero point is the melting point of ice and the 100° point is the boiling point of water, both points at standard atmospheric pressure.

Charles' law or Gay-Lussac's law.—At a constant pressure, the volume of a given quantity of a gas varies directly as the absolute temperature to which the gas is subjected; or at a constant volume, the pressure of a given quantity of a gas varies directly as the absolute temperature.

Chinook.—A warm, dynamically heated wind of the western Great Plains of the United States and Canada. Same as a foehn wind.

Cirrocumulus.—A layer of clouds of generally cirrus character composed of small white flakes or of very small globular masses, usually without shadows, which are arranged in groups, or lines, or ripples.

Cirrostratus.—A cloud having the appearance of a thin whitish veil, which does not blur the outline of the sun or moon, and which often causes halos.

Cirrus.—Detached clouds of delicate and fibrous appearance, without shading, generally white in color, often of a silky appearance.

Climate.—The average condition of a locality or region with respect to the various atmospheric variables, such as temperature, rainfall, wind, etc.

Climatology.—The science of climate.

Cloudburst.—A sudden and very heavy rainfall.

Col.—An area on an isobaric map between two high pressure centers though lacking closed isobars. May be compared to a mountain pass between two peaks on a topographic map. Sometimes called a "saddle".

Cold front.—The advancing edge of a cold mass of air.

Cold sector.—The portion of a wave cyclone to the rear of the cold front and in advance of the warm front.

Cold wave.—A sudden and considerable fall in temperature to a relatively low value usually affecting a large area.

Condensation.—The change from the vapor phase to the liquid phase of a substance.

Conditionally unstable.—A body of air in which the temperature lapse rate lies between the dry and the saturated adiabatic rates is said to be conditionally unstable. A particle of air which is lifted in such a body of air will eventually become warmer than its surroundings and rise of its own accord.

Conduction.—The transfer of heat through and by means of matter without any necessary movement of matter.

Convection.—The transfer of heat by moving matter.

Convectively unstable.—A layer of air which is stable, but which will become unstable on being lifted is said to be convectively unstable. The equivalent potential temperature of such a layer decreases aloft, whereas the potential temperature increases.

Convergence.—Often applied to the converging of air into a region as a result of a particular pressure and isallobaric distribution.

Coriolis force.—The deviating force exerted on a particle in motion due to the rotation of the earth on its axis. Directed to the right in the northern hemisphere and to the left in the southern hemisphere. Zero at the equator.

Corona.—Rainbow colored rings, usually only a few degrees in radius, surrounding the sun, moon, or other bright object, when covered by a thin cloud veil.

Cumulus.—Dense clouds with a vertical development; the upper surface is dome shaped and exhibits rounded protuberances, while the base is nearly horizontal.

Cumulonimbus.—Heavy masses of cloud, with great vertical development, whose cumuliform summits rise in the form of mountains or towers, the upper parts having a fibrous texture and often spreading out in the shape of an anvil.

Cyclogenesis.—The meteorological process or processes which lead to the intensification of a cyclone.

Cyclolysis.—The meteorological process or processes which lead to the weakening of a cyclone.

Cyclone.—Has at least two meanings in meteorology, excluding the popular idea of a cyclone as meaning a tornado.

a. An atmospheric pressure system characterized by relatively low pressure at its center. Characterized by counterclockwise winds in the northern hemisphere and clockwise winds in the southern hemisphere.

b. A tropical hurricane of the Indian Ocean is called locally a cyclone.

Cyclostrophic.—The force which enters into the balance of forces acting on a particle of air, which is the result of the centrifugal force due to the particle's motion in a curved path, is called the cyclostrophic force.

Dalton's law.—The pressure of a mixture of several gases in a given space is equal to the sum of the partial pressures which each gas would exert if it were confined alone in the space.

Declination (magnetic).—The angle between the magnetic needle and the true north-south line.

Deepening.—Decrease of pressure within a pressure center.

Density.—The ratio of mass per unit volume, as grams per cubic centimeter.

Depression.—Used as a synonym for a cyclonic pressure center.

Deviating force.—Same as Coriolis force.

Dew.—Liquid water droplets which condense on the surfaces of objects, usually at night.

Dew point.—The temperature at which condensation begins in a given sample of air as it is cooled.

Diurnal.—Daily.

Divergence.—The flowing of air out of a region as the result of a particular pressure and isallobaric distribution.

Doldrums.—The region of relatively calm winds near the equator.

Drizzle.—Precipitation consisting of very numerous, minute droplets of water whose size is less than 1/50 inch in diameter.

Dry adiabat.—A line on a pressure-temperature chart which represents the rate of cooling or heating of a particle of air while it is unsaturated.

Dust devil.—A miniature whirlwind, usually only a few feet in diameter and a few hundred feet in height, of frequent occurrence on hot summer days in plains areas, such as the western United States. The whirlwind picks up dust and rubbish and carries it some distance into the air, hence its name.

Dyne.—The metric unit of force. The force required to give an acceleration of 1 centimeter per second per second to a mass of 1 gram.

Ecliptic.—The plane described by the earth in its path around the sun.

Eddy.—A current of air or a wind which blows contrary to the main current.

Entropy.—A fundamental concept of thermodynamics which is equal to $\int\frac{dQ}{T}$. It is usually designated by the Greek letter ϕ. It is dependent on the quantity of heat in a body and its temperature. It depends only on the state of the substance and is independent of the sequence of changes by which that state was reached.

Equation of time.—The difference between mean solar time and apparent solar time.

Equinoxes.—The points in the earth's orbit at which the sun crosses the equator. The vernal equinox occurs on March 21, and the autumnal equinox on September 23, in the northern hemisphere. Day and night are equal on these dates, hence the name.

Equivalent potential temperature.—The temperature a particle of air will assume if lifted until all moisture is precipitated, then lowered to 1000 millibars. Usually designated by θ_e.

Equivalent temperature.—The temperature a particle of air will assume if lifted until all mositure is precipitated, then lowered to its original level.

Erg.—The elementary metric unit of work. The amount of work produced by a force of 1 dyne acting through 1 centimeter.

Eulerian.—A type of wind in which the existing pressure gradient is balanced mainly by the acceleration of the air.

Evaporation.—The change from the liquid to the vapor phase of a substance.

Eye (of hurricane).—The central region of approximate or actual calm conditions, and often clear skies, in the center of a tropical hurricane. The atmospheric pressure of the storm will attain the minimum value here.

Fahrenheit.—A widely used temperature scale in which the melting point of ice is 32° and the boiling point of water is 212°, both points at atmospheric pressure.

Fall.—See autumn.

False cirrus.—Cirrus proceeding from a cumulonimbus cloud and composed of the debris of the upper frozen parts of these clouds. This cloud type now generally called cirrus nothus.

Filling.—Increase of pressure within a pressure center.

Foehn (föhn).—A warm, dry wind which has been heated by compression as it descends an orographic barrier. The type region is the Alps.

Fog.—Water vapor which has condensed in the form of minute water droplets in the lower part of the atmosphere and interfering with its transparency. It differs from cloud only in its being near or at the surface. It is easily distinguished from haze by its essential wetness.

Fortin barometer.—A type of very accurate mercurial barometer with an adjustable cistern holding the mercury.

Fractocumulus.—Very low, ragged clouds of slight cumuliform development which often appear beneath nimbostratus clouds during active precipitation.

Fracto-stratus.—Very low, ragged clouds of stratiform appearance which often appear beneath nimbostratus clouds during active precipitation.

Front.—An atmospheric discontinuity surface separating two different air masses.

Frontogenesis.—A process which tends to concentrate the solenoid field between two air masses, and hence leads to the formation of a front, or to the intensification of an existing front.

Frontolysis.—A process which tends to destroy the solenoid field between two air masses and hence leads to the destruction of a front.

Frost.—Ice crystals which sublime on the surfaces of objects, usually at night, to form a feathery coating.

Gale.—A wind of relatively high velocity. According to the Beaufort scale of wind velocities, gales are subdivided into moderate, fresh, strong, and whole gales, with a complete range of velocities from 32 to 63 miles per hour.

Gay-Lussac's law.—See Charles' law.

Geopotential.—The potential energy of unit mass at a point Z above the surface of the earth. It is equal to the work done in lifting unit mass from mean sea level up to that point. It is equal to $\int_0^Z gdZ$, or approximately, neglecting the variation of g with height, to gZ.

Geostrophic wind.—The wind, blowing along straight isobars, which produces a Coriolis force that will just balance the existing pressure gradient. Neglects centrifugal force.

Gradient.—A vector which measures the direction and magnitude of the greatest rate of decrease of a function.

Gradient wind.—The wind, blowing along the isobars, which produces a Coriolis force and a centrifugal force, that will just balance the existing pressure gradient.

Gram.—The unit of mass of the metric system.

Graupel.—See snow pellet.

Gravity.—The acceleration of terrestrial bodies toward the center of the earth.

Gulf Stream.—A strong, warm current of the North Atlantic Ocean, which starts between Florida and Cuba and flows northeastward toward northern Europe.

Gust.—Any sudden change in the velocity of the wind.

Hail.—Ice balls or stones, with diameters ranging from ⅕ inch to 2 inches or even more, which either fall detached, or fused in irregular lumps. They are either quite transparent or composed of alternating clear and opaque, snow-like layers, the clear layers being at least $\frac{1}{25}$ inch thick. Hail occurs almost exclusively in violent or prolonged thunderstorms and never with temperatures below freezing at the ground. Extremely dangerous to aircraft.

Hail stage.—The stage during the cooling of air by continued lifting, during which the temperature is supposed to remain constant at 0° C. while the liquid water which is present freezes. Because of the wide prevalence of subcooled water in the atmosphere, the hail stage is no longer considered to represent truly actual atmospheric conditions.

Halo.—A circle of light appearing to surround a luminous body, especially the sun, or the moon. The result of refraction of light by ice crystals.

Haze, damp.—Small water droplets or very hygroscopic particles suspended in the atmosphere, with the horizontal range of visibility usually considerably more than 1¼ miles. Similar to a very thin fog, but the droplets or particles are more scattered than in light fog and presumably also smaller. This phenomenon is usually distinguished from dry haze by its grayish color, the "greasy" appearance of clouds seen through it, as though viewed through a dirty window pane, and the generally high relative humidity. Commonly observed on seacoasts and in southern states.

Haze, dry.—Dust or salt particles which are dry and so extremely small that they cannot be felt or discovered individually by the unaided eye; however, they diminish the visibility and give a characteristic smoky (hazy and opalescent) appearance to the air. This phenomenon produces a uniform veil over the landscape and subdues its colors. This veil has a bluish tinge when viewed against a dark background, such as a mountain, but has a dirty yellow or orange tint against a bright background, such as the sun, clouds at the horizon, or snow-capped mountain peaks. It is distinguished thus from grayish light fog, the thickness of which it may sometimes attain.

Heat.—A form of energy whose quantity is measured by the change of temperature produced. The unit of heat is the calorie (metric units) or the British thermal unit (English units). The British thermal unit is the heat required to raise the temperature of 1 pound of water, 1° F., at its maximum density. It is equal to 252 calories.

Heliotropic.—A wind which appears to follow the sun, changing its direction as the sun moves through the sky.

High.—A pressure system characterized by relatively high pressure at its center.

Hoar frost.—See frost.

Horizon.—The apparent junction of the earth and sky.

Horse latitudes.—The region of comparatively light westerly winds, found in the subtropical high pressure belt.

Humidity.—In general, the moisture content of the atmosphere.

Humidity, absolute, relative, etc.—See absolute humidity, relative humidity, etc.

Hurricane.—An extremely violent cyclonic storm of the tropics. Characterized by a calm central eye a few miles in diameter, in which the atmospheric pressure is very low, and a surrounding cyclonic vortex of great intensity. The hurricane is usually accompanied by torrential rains. It originates in regions near, but not on the equator, and then moves rather slowly westward and poleward until it reaches about latitude 25° to 30° when it "recurves" toward the east, as its speed increases.

Hydrometeor.—Bodies of solid or liquid water which fall through the air.

Hydrometer.—An instrument used to measure the density of liquids.

Hydrograph.—An instrument designed to record the atmospheric humidity.

Hygrometer.—An instrument designed to measure and indicate the atmospheric humidity.

Hygroscopic.—Has a strong affinity for moisture.

Indian summer.—A term of the United States and Canada for a period of mild weather which often occurs in the late autumn or early winter.

Infrared.—Light having a wavelength longer than the visible (over 7000 Ångstrom units).

Insolation.—Solar radiation.

Interpolation.—The process of inserting intermediate terms in a mathematical series.

Inversion (temperature).—A reversal in the normal temperature lapse-rate, in which the temperature rises with increased elevation, instead of falling.

Ionosphere.—The very high levels of the atmosphere, in which the gases are more or less ionized, due to the low pressure. It is more than 60 miles high above the stratosphere.

Isallobar.—A line or surface connecting points having equal pressure changes.

Isentropic.—Having the same entropy. Often applied, in meteorology, to a surface of constant potential temperature. Entropy is directly proportional to the log of the potential temperature.

Isobar.—A line or surface connecting points having the same pressure.

Isostere.—A line or surface connecting points having the same specific volume.

Isotherm.—A line or surface connecting points having the same temperature.

Isothermal.—A physical process which takes place without change in temperature. Opposed to adiabatic, where the process takes place without change in heat content.

Japanese current.—A warm current of the western portion of the North Pacific Ocean. Starting off southeastern China, it flows northeastward past the Japanese islands, then continues into the Aleutian region of North America.

Joule.—A widely used unit of work. It is equal to 10^7 ergs. One calorie of heat requires the expenditure of 4.18 Joules of mechanical work.

Katabatic.—A down-slope wind of the gravity type.

Katallobar.—A region of maximum pressure falls. An isallobaric low.

Kelvin.—A temperature scale whose zero point lies at absolute zero (−273° C.). Same as absolute temperature.

Kuro-Shiwo.—Same as Japanese current.

Lag.—The failure of an indicating device to indicate variations immediately in the property being measured.

Land breeze.—A light (usually) breeze blowing offshore at a time when the land is cooler than the ocean.

Lapse-rate.—The rate of decrease of temperature with elevation.

Latent heat of fusion.—The quantity of heat necessary to change 1 gram of a solid to a liquid with no change in temperature. Measured in calories per gram.

Latent heat of vaporization.—The quantity of heat necessary to change 1 gram of a liquid to vapor with no change in temperature. Measured in calories per gram.

Latitude.—The angular distance of a point, north or south of the equator.

Lenticular.—Lens shaped. Sometimes applied to the appearance of clouds, as lenticular altostratus.

Line squall.—The severe squall which may appear along an active cold front, especially one involving relatively unstable warm air.

Longitude.—The angular distance of a point, east or west of a standard meridian, usually that of Greenwich.

Low.—A pressure system characterized by relatively low pressure at the center.

Lunar.—Pertaining to the moon, as a lunar halo.

Mackerel sky.—A popular name for cirrocumulus clouds.

Mammato-cumulus.—A type of cumulus cloud in which the lower surface bulges downward in a number of places to produce rounded protuberances.

Mare's tails.—A feathery, spreading cirrus cloud.

Meniscus.—The rounded upper surface of a column of liquid. May be either concave or convex upward, depending on the surface tension of the liquid. Thus water produces a concave meniscus, while mercury produces a convex one.

Mercator's projection.—A map projection in which both parallels of latitude and meridians of longitude appear as straight lines. This is a so-called cylindrical projection.

Meteor.—A small body from space encountered by the earth, which becomes incandescent on striking the earth's atmosphere. A shooting star.

Meteorograph.—An instrument carried aloft by a balloon or by an airplane, which records the temperature, pressure and humidity as it ascends through the atmosphere.

Meteorology.—The science or study of the atmosphere.

Meter.—The fundamental unit of length in the metric system. Equal to 39.37 inches.

Microbarograph.—An instrument of great sensitivity used to record the atmospheric pressure.

Micron.—A very small unit of length. Equal to one-millionth of a meter (10^{-6} meter). Usually designated by μ.

Millibar.—A widely used unit of atmospheric pressure. Equal to $1/1000$ bar or 1,000 dynes per square centimeter. One millibar=0.0295299 inch of mercury.

Mirage.—An optical effect, sometimes observed on plains or deserts, caused by total reflection of light at the surface between two strata of air of different temperatures. The image of an object thus reflected is usually inverted, while the real object may not be in sight.

Mist.—A term employed in England for a very light fog. Formerly employed in the United States for drizzle. Not now in use in the United States.

Mistral.—A term used along the French-Italian Riviera for a cold gale. Similar to the norther of the United States.

Mixing ratio.—A measure of humidity. Equal to the mass of water contained in a given mass of *dry* air. Generally expressed in grams of water per gram or kilogram of dry air. Usually designated as w or W.

Moist adiabat.—A line on a pressure-temperature diagram which represents the rate of cooling of an air particle as it is raised in the atmosphere, after it becomes saturated.

Monsoon.—A seasonal wind, which blows from the land to the adjoining ocean or vice versa in response to the temperature gradient established at that season of the year. Typically developed in India. Often applied to any wind which reverses with the seasons.

Mother-of-pearl clouds.—See nacreous clouds.

Mountain breeze.—A breeze blowing from a mountain to an adjoining valley. Partially due to temperature differences between the cool mountain and the warmer valley, and partially due to gravity flow of the cold air down the mountain slopes. Blows at night.

Nacreous clouds.—Rare clouds of the stratosphere exhibiting a remarkable play of colors. The colors extend, band after band, into the cloud center, in distinction from the so-called iridescent clouds of the troposphere, where the colors are arranged in fringes around the edges of the cloud. Nacreous clouds are always observed on the west side of cyclones, when the sky is clear due to foehn effects. There is some doubt concerning the nature of the cloud particles, and they may be either ice crystals or subcooled water droplets. Nacreous clouds appear at heights of between 27 and 30 kilometers above the surface of the earth.

Nephoscope.—An instrument for observing and measuring the motions of clouds.

Nimbostratus.—A low, formless cloud layer, of a dark grey color, and nearly uniform. Precipitation falls in the form of rain or snow.

Nimbus.—An older term for clouds from which precipitation is falling, together with the low clouds beneath. Now superseded by the terms nimbostratus, fractostratus, and fractocumulus.

Noctiluscent clouds.—Extremely thin clouds, visible only after sunset, which appear at great heights in the stratosphere (around 80 kilometers above the surface). Possibly composed of cosmic dust particles. Very rare.

Norther.—A term used in the Gulf Coast region of the United States for a cold gale from the north. Formed by a vigorous outbreak of continental polar air behind a cold front during the winter.

Occlusion or occluded front.—The front resulting when a cold front overtakes a warm front, forcing the warm sector aloft.

Orographic.—Pertaining to mountains, as orographic rain.

Overcast.—A cloud layer which covers over nine-tenths of the sky.

Ozone.—A gas whose molecules consist of three atoms of oxygen (O_3).

Ozone layer.—A rather restricted region in the upper atmosphere in which much of the ozone is concentrated. Elevation about 25 kilometers.

Pampero.—A cold southerly wind of the Argentine Pampas.

Parallax.—The apparent displacement of an object when viewed from two or more different points.

Paraselene (plural paraselenae).—A bright spot in a lunar halo, having the same elevation as the moon. Occurs in the direction of minimum refraction by the ice crystals which produce the halo. Also called "moon dogs", or "mock moons."

Parhelion (plural parhelia).—A bright spot in a solar halo, having the same elevation as the sun. Occurs in the direction of minimum refraction by the ice crystals which produce the halo. Also called "sun dogs", or "mock suns."

Partial potential temperature of dry air.—The temperature which a sample of air would assume if lowered (or raised) to a standard pressure of 1,000 millibars, neglecting the presence of water vapor. (Usually designated as θ_d.)

Perihelion.—That point in a planet's orbit which is closest to the sun. For the earth this occurs on January 1.

Pitot tube.—A tube of small bore placed with its open end in a moving fluid, so that the pressure exerted in the tube may be measured, and thus indicate the velocity of the fluid.

Polar front.—The more or less permanent boundary between the cold polar easterly winds and the relatively warm southwesterly winds of the middle latitudes.

Potential temperature.—The temperature which a sample of air would assume if lowered (or raised) along a dry adiabat to a standard pressure of 1,000 millibars. Usually designated by θ. No condensation may occur.

Precipitable water.—The thickness of the layer of water that would result if all of the water vapor in the atmosphere above a given point were condensed at a given time.

Precipitation.—Falling products of condensation or sublimation, such as rain, snow, hail, drizzle. Precipitation elements are usually larger than 10^{-2} centimeter. Particles smaller than this size usually remain supported in the air as clouds.

Pressure.—The force applied over a surface divided by its area. Expressed in units of force per unit area, as dynes per square centimeter.

Psychrometer.—An instrument used to measure atmospheric humidity. It consists of two thermometers, the bulb of one of which is kept moistened. When ventilated by forcing air over the thermometer bulbs, it yields two temperature readings—the dry-bulb and the wet-bulb reading. By means of suitable tables, these readings may readily be converted to various forms of the atmospheric humidity.

Pyrheliometer.—An instrument used to measure the sun's heat and energy.

Radiation.—The transfer of energy through space without the necessary presence of matter.

Radiosonde.—An instrument carried aloft by means of a balloon or an airplane which sends, by means of a miniature radio transmitting set, the atmospheric temperature, pressure, and humidity encountered.

Rain.—The falling from clouds of drops of water (in the liquid state) in which most drops are larger—or if not larger, then much sparser—than the drops in drizzle; that is, the diameter of most drops is greater than 1/50 inch, they fall in still air faster than 10 feet per second.

Rainbow.—An optical refraction phenomenon consisting of a circular arc composed of alternating bands of color, seen in the sky during rainstorms, when the clouds break sufficiently to allow the sun to illuminate part of the sky. Rainbows are invariably less than a semicircle unless viewed from an elevated location. They result from refraction within water droplets, of light from the sun.

Rain stage.—The stage during dynamic cooling of a mass of air in which liquid water is condensed.

Reaumur.—A rarely employed temperature scale in which the melting unit of ice is 0° and the boiling point of water is 80°. Used to a slight extent in Europe, but has been replaced largely by the centigrade scale.

Reduction to sea level.—The process of calculating the atmospheric pressure which an elevated station would have if it lay at sea level.

Reflection.—The return of waves of light or sound after striking surfaces.

Refraction.—The deflection from a straight line suffered by a ray of light or sound as it passes obliquely from one medium to another in which the velocity of transmission is different. For example, light will be refracted in passing obliquely from air into water.

Refsdal diagram.—An adiabatic chart in which the coordinates are temperature on a horizontal linear scale, and pressure to the 0.288 power on a vertical scale.

Relative humidity.—The ratio of the actual vapor pressure to the saturated vapor pressure. Usually designated by f.

Ridge.—On an isobaric map, an elongated area of relatively high pressure.

Rime.—A white, opaque, granular structure consisting of very small ice particles which have little cohesion.

Roaring forties.—The very strong westerly winds of the middle latitudes of the southern hemisphere.

Rossby diagram.—A thermodynamical diagram with coordinates of specific humidity on a horizontal linear scale, and partial potential temperature of the dry air on a vertical logarithmic scale. Sloping lines of constant equivalent potential temperature are also included.

Saint Elmo's fire.—A brush discharge of electricity which appears on sharp points or edges of objects during the existence of strong electrical fields. It may appear as a general glow over the object, or as numerous short luminous streamers projecting into the air. It is often seen on the wing tips and propellers of aircraft flying in or near thunder clouds.

Saturation.—Applied to the atmosphere to mean the condition when the pressure of water vapor present represents equilibrium with a water or ice surface.

Scalar.—A quantity which has magnitude but not direction. Time, length, mass are scalar quantities. See vector.

Scattering.—The absorption and reradiation of incident light by very small particles, or gas molecules. Scattering is greater for the shorter wavelengths of light, thus greater for blue light than for red. The scattering particles must be smaller than the wavelength of the light which they are to scatter.

Scotch mist.—A drizzle or light rain, caused by orographic lifting of maritime polar air.

Scud.—A popular name for the low, drifting clouds which often appear beneath a cloud from which precipitation is actively falling. The official name for these clouds is fractostratus, or fractocumulus, depending upon their exact form.

Sea breeze.—A thermally produced wind blowing from the cool ocean surface onto the adjoining warm land, usually during summer.

Sea level.—The level of the surface of the sea. More specifically, mean sea level is the position between mean high and mean low water adopted as a standard for the measurement of elevations.

Secondary cold front.—A cold front which forms behind the main cold front during periods of strong temperature and pressure gradients. Occurs only during the cold season.

Shower.—A shower is characterized by the suddenness with which the precipitation (rain, snow, snow pellets, etc.) starts or stops and by its rapid changes of intensity, also by the aspect of the sky—rapid changes between dark, threatening clouds and clearings of the sky (of short duration, often with an intensely blue sky). Sometimes no definite clearing occurs between the showers, or the precipitation does not even stop entirely between them; the shower character of the precipitation is then revealed by the more or less rapid alternations of lighter and darker clouds.

Sirocco.—A hot wind blowing in the warm sector of a cyclone. May be either dry or moist, depending on the type of air and its trajectory. Type region is Italy.

Sleet.—Transparent, globular hard grains of ice, ranging from $1/25$ to $4/25$ inch in size which fall from clouds. They rebound when falling on hard surfaces. They are usually produced as a result of the coalescence of snow flakes or snow pellets and subcooled water.

Snow.—White or translucent ice crystals or flakes, mainly in branched hexagonal shapes (stars), often mixed with simple ice crystals.

Snow pellet.—White, opaque, round, or occasionally conical, grains of snow-like structure, $1/16$ to $1/4$ inch in diameter, which fall from clouds. The pellets are crisp and easily compressible, rebound when falling on hard ground and thereby often burst. They occur almost exclusively in showers.

Snow stage.—The stage during the dynamic cooling of a mass of air during which solid water (snow) is sublimed.

Solar altitude.—The angle between the horizon and the line joining the observer and the sun.

Solar constant.—The quantity of radiant solar heat received at the outer layers of the earth's atmosphere, measured in calories per square centimeter of surface normal to the direction of transmission of the radiation, per minute. The average value of the constant is 1.94 calories per square centimeter per minute. This is subject to small periodic fluctuations.

Solstices.—The points in the earth's orbit at which the sun is farthest from the equator. At the solstices, the earth's axis and the line joining the earth and the sun determine a plane which is perpendicular to the ecliptic. In the northern hemisphere the summer solstice (longest day) occurs about June 21, the winter solstice (shortest day) about December 22.

Specific heat.—The ratio of the heat capacity of a substance to that of water at 15° C.

Specific humidity.—A measure of humidity. The mass of water contained in a given mass of moist air. Generally expressed in grams of water per gram or kilogram of moist air. Usually designated as q or Q.

Spring.—The season of the year between winter and summer. Usually considered to consist of the months of March, April and May. Also reckoned astronomically as extending from the vernal equinox (March 21) to the summer solstice (June 21).

Squall.—A sudden, violent rain or snow storm accompanied by strong, gusty winds.

Squall line.—An active cold front, especially if it is moving rapidly and involves unstable warm air.

Stability.—The resistance of a body of air to displacements of air particles within it.

Standard atmosphere.—A hypothetical state of the atmosphere in which the pressure, temperature, lapse rate, etc., are given arbitrary values, in order that this atmosphere may be used as a standard of comparison to be used in various meteorological and aerodynamical calculations.

Stratocumulus.—A cloud layer, or patches of clouds, composed of laminae, globular masses or rolls; the smallest of the regularly arranged elements are fairly large; they are soft and gray, with darker parts. These elements are arranged in groups, in lines, or in waves, aligned in one or in two directions. Very often the rolls are so close that their edges join; when they cover the whole sky they have a wavy appearance.

Stratosphere.—The upper portion of the atmosphere, above the troposphere and below the ionosphere. Its lower limit varies from about 8 to about 20 kilometers; its upper limit lies at about 100 kilometers. The base of the stratosphere marks an upper limit to the general convective activity of the troposphere. Air motion within the stratosphere is largely horizontal.

Stratus.—A low uniform layer of cloud, resembling fog, but not resting on the ground.

Subcooled water.—Water which has been cooled below 0° C. without freezing.

Subsidence.—The sinking and spreading out of a body of air, usually within an anticyclone.

Summer.—The season of the year generally considered to consist of the months of June, July and August. Also reckoned astronomi-

cally as extending from the summer solstice (June 21) to the autumnal equinox (Sept. 23).

Summer solstice.—The point in the earth's orbit at which the sun is farthest from the equator and in this hemisphere. It may be defined as the time when the earth's axis, and the line joining the earth and sun determine a plane which is perpendicular to the ecliptic, and the end of the earth's axis in the hemisphere being considered points toward the sun. It occurs on June 21 in the northern hemisphere and December 22 in the southern hemisphere. The longest day of the year occurs on this date.

Sun pillar.—A vertical shaft of white light, extending above and below the sun, occasionally seen during very cold weather. It is caused by reflection from tubular shaped ice crystals in the atmosphere.

Swell (sea).—Wave motion of the ocean surface.

Sylphon.—The partially evacuated metal cell or series of cells comprising the actuating mechanism of an aneroid barometer.

Synoptic chart.—A chart of a wide region prepared from data compiled as a result of observations taken at the same time.

Telethermoscope.—An instrument designed to measure the temperature and to indicate it at a distance from the point of measurement.

Temperature.—The degree of hotness or coldness of a substance. It is measured on a scale which is based on definite physical changes. Temperature measures the average kinetic energy of the molecules of a substance. The lower limit of temperature is absolute zero, $-273°$ C. There is no theoretical upper limit to temperature. The highest temperature produced on the earth is about 25,000° C.

Temperature, absolute, equivalent, Fahrenheit, etc.—See absolute temperature, equivalent temperature, Fahrenheit temperature, etc.

Tendency.—The rate of change of the atmospheric pressure.

Tephigram.—A thermodynamical diagram with coordinates of absolute temperature on a horizontal axis and entropy on a vertical axis, both on linear scales. The entropy scale is usually replaced by a logarithmic scale of potential temperature, to which it is equivalent.

Theodolite.—An instrument consisting of a telescope mounted so that it can be revolved about both its vertical and horizontal axes, used for measuring the vertical and horizontal angles to various points. Used in meteorology to observe pilot balloons in order to determine the direction and velocity of the winds aloft.

Thermogram.—The record of temperature as recorded by a thermograph.

Thermograph.—An instrument designed to record the temperature.

Thermometer.—An instrument designed to measure and indicate the temperature.

Thunder.—The sound produced by a flash of lightning. It is caused largely by the sudden expansion of air in the lightning path resulting from the heat released during the electric discharge.

Thunderstorm.—Any storm which is accompanied by thunder.

Torricelli tube.—A glass tube about 80 to 100 centimeters long, sealed at one end, and open at the other, and filled with mercury, the open end of which is then placed in a vessel of mercury. The mercury is then allowed to descend until the pressure exerted by its column just balances the existing atmospheric pressure.

Tornado.—A very intense, sharply defined, funnel-shaped storm of the United States prairies. The most violent and sharply defined of all storms.

Trade winds.—The winds on either side of the equatorial belt of calms blowing from the northeast in the northern hemisphere and from the southeast in the southern hemisphere. They are relatively very constant in direction and velocity.

Tropopause.—The boundary between the troposphere and the stratosphere.

Troposphere.—The lower part of the atmosphere lying between the surface of the earth and the tropopause. Marked by a steady average decrease of temperature with altitude, and considerable turbulence.

Trough.—On an isobaric map, an elongated area of relatively low pressure.

Typhoon.—A tropical cyclonic storm of great intensity. Same as a hurricane.

Ultraviolet.—That portion of the spectrum having a wavelength less than about 4000 Ångstrom units.

Valley breeze.—A breeze blowing from a valley to an adjoining mountain due to the temperature difference. Blows during the day.

Vapor pressure.—The pressure exerted by the vapor of a liquid. In meteorology usually used to designate the vapor pressure of water.

Vector.—A quantity which has both magnitude and direction. Force, acceleration, velocity, are vector quantities. See scalar.

Veer (wind).—A clockwise change in the wind direction.

Velocity.—The rate of motion in a given direction and sense.

Vernal equinox.—The point between the winter solstice and the summer solstice at which the sun crosses the equator. Occurs on March 21 in the northern hemisphere and on September 23 in the southern hemisphere. Day and night are equal on this date.

Vernier.—A short scale arranged to slide along the graduations of the main indicating scale of an instrument. The vernier is graduated

so that a certain number of its divisions are just equal to one more or less than the same number of divisions on the main scale. Parts of divisions on the main scale are determined by observing which line on the vernier is coincident with a line on the main scale.

Virga.—Streamers of precipitation falling from a cloud which do not reach the ground.

Virtual temperature.—The temperature of damp air at which dry air of the same pressure would have the same density as the damp air. It is always higher than the actual temperature.

Viscosity.—That property of a liquid which determines its resistance to flow.

Visibility.—The distance at which objects may be seen in a horizontal direction by the unaided eye.

Warm front.—The advancing edge of a warm mass of air.

Warm sector.—The portion of a wave cyclone in front of the cold front and to the rear of the warm front.

Waterspout.—A whirlwind over water, formed on hot days, in which water droplets and cloud particles are carried some distance (from a few feet to several hundred feet) into the air. In rare cases a tornado may appear over the water and give rise to an exceptionally severe form of waterspout.

Wave motion.—A vibratory motion characterized by the occurrence of waves.

Weather.—The state of the atmosphere at a given moment with respect to temperature, moisture, cloudiness, precipitation, or other meteorological phenomena.

Wedge.—On an isobaric map, an elongated area of relatively high pressure.

Wet bulb.—The bulb of the thermometer on a psychrometer which is kept moistened when taking humidity measurements.

Wet-bulb potential temperature.—The temperature which a parcel of air would assume if lowered (or raised) along the moist adiabat through its wet-bulb temperature, to a standard pressure of 1,000 millibars.

Wet-bulb temperature.—The temperature indicated by the wet-bulb of a psychrometer.

Whirlwind.—A rapidly whirling vortex of air, with its axis vertical or nearly so, usually seen on hot, still days. The diameter and height of a whirlwind may vary from a few feet to several hundred feet. Characterized by the inflow of air at the base of a corresponding outflow aloft.

Williwau.—A cold, gravity (Bora-type) wind of the Strait of Magellan and Tierra del Fuego.

Wind.—Air in motion.

Wind rose.—A diagram which shows for a given locality or area the frequency and strength of the wind from various directions.

Wind vane.—A device consisting of an arm, free to rotate with the wind, used to indicate the wind direction.

Winter.—The season of the year generally considered to include the months of December, January and February. Also reckoned astronomically as extending from the winter solstice (December 22) to the vernal equinox (March 21).

Winter solstice.—The point in the earth's orbit at which the sun is farthest from the equator and in the other hemisphere. It may be defined as the time when the earth's axis, and the line joining the earth and sun determine a plane which is perpendicular to the ecliptic, and the end of the earth's axis in the hemisphere being considered points away from the sun. It occurs on December 22 in the northern hemisphere and June 21 in the southern hemisphere. The shortest day of the year occurs on this date.

Zenith.—That point in the sky directly overhead.

Zenith distance.—The angle between the vertical and the line joining the observer and the object being observed. This is the complement of the object's elevation angle.

Zodiac.—An imaginary belt in the heavens, 16° wide, including the paths of the moon and all of the principal planets, with the ecliptic as its center line. The zodiac has 12 equal divisions.

Zonda.—A Chinook-type wind of Argentina.

Appendix III

ACKNOWLEDGMENT

It is desired to acknowledge the cooperation of the United States Weather Bureau and the Civil Aeronautics Administration in allowing free use of material contained in their publications.

Through the courtesy of the Julian P. Friez Company permission was granted to use photographs and descriptive material of a number of their instruments.

INDEX

INDEX

INDEX

INDEX

INDEX

462750°—12——43

[A. G. 062.11 (5–1–42).]

BY ORDER OF THE SECRETARY OF WAR:

G. C. MARSHALL,
Chief of Staff.

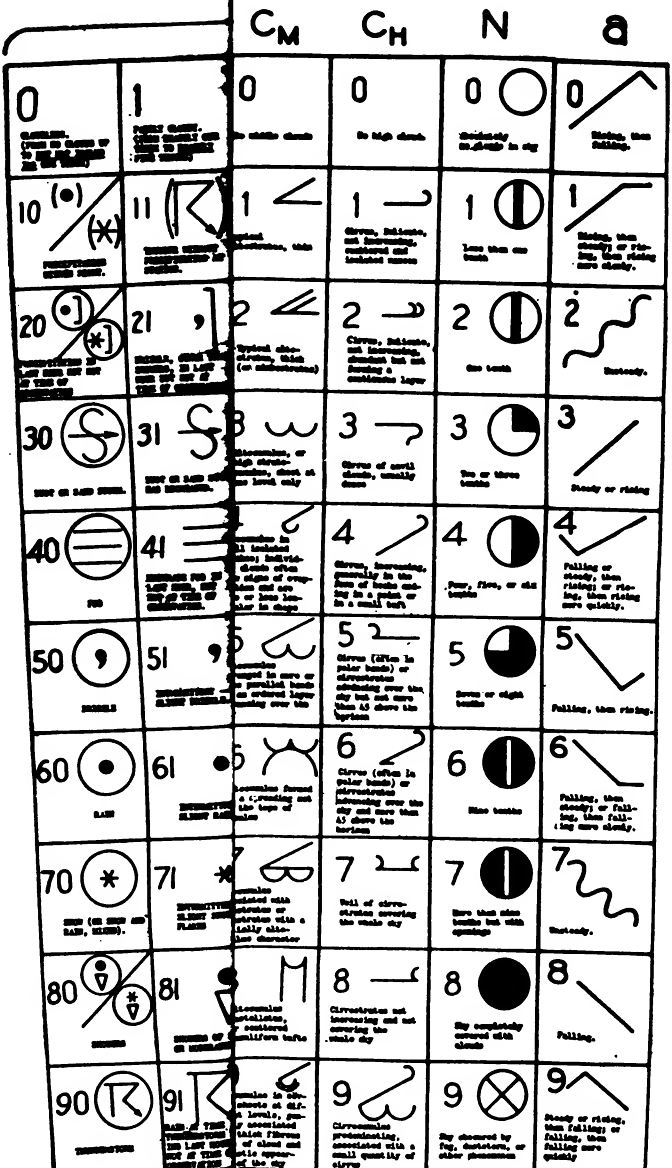
OFFICIAL:

J. A. ULIO,
Major General,
The Adjutant General.

DISTRIBUTION:

B and H 1 (2); IBn 1 (10).
(For explanation of symbols see FM 21–6.)

SYMBOLS



ING RAIN

462750°
U. S. GOVERNMENT PRINTING OFFICE: 1942